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The Coal Producers' Losing Victory

THE coal producers and distributers stand discredited today in the eyes of the American people as administrators and purveyors of the fuel resources of the country.

They have refused, as the peoples' agents for the economical gathering and distribution of their coal supply, to render an account of their stewardship or to permit the Government access to their records of production, costs and sales.

They have defeated legislation framed and favored, not by extremists who would stifle initiative, socialize production and confiscate property, but by sane, conservative publicists who, realizing the essentiality of its fuel supply to the industrial and social life of the nation, asked that they who have to legislate for the general welfare be given access to the facts about one of the most important items involved.

The American people are ready to believe that great businesses like the coal industry can be conducted more wisely and efficiently under private control than through public or collective, or Governmental agencies. Anything like the nationalization of even so communal and necessary a matter as the coal supply would have found little favor a few years ago. But if any Government Department had made such a mess of the administration of the coal supply as has been made of it under private "enterprise" during the last half-dozen years, nationalization or Governmental management of common resources would be forever discredited in the mind of its most ardent advocate.

The fuel resources of the country are not commodities to be snatched by those who see them first and held from their fellows for a price. What the producer sells is not coal but service—the service of finding and digging the mine, the service of winning and preparing the coal. The best way to set the people to thinking whether they had not better get this service in some other way is to make it as expensive and inadequate as it has been of recent years and then tell the public to mind its business when it begins to inquire why it is so.

If a man is afraid or ashamed to show his figures, the time to watch him began some time ago.

F. R. LOW.

Concentration of Water in Steam Boilers

By VICTOR J. AZBE
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EVEN in the present day of relatively exact methods of power-plant operation, the blowing down of boilers is a crude procedure based in most cases on nothing more than guesswork. The real basic principles are not realized and a great many false ideas exist, primarly because in the past no convenient, and at the same time accurate, apparatus was available for determining the concentration of the water with matter in solution.

As an example of misapprehension that exists, it may be stated, a certain publication advises that concentration should be kept below 100 grains per gallon. If it is taken into consideration that many a water while being fed to the boiler contains as much as 50 grains of solubles per U. S. standard gallon, it will be seen that to maintain the concentration such as advised previously, half of the water fed to the boiler would have to be blown off to the sewer. Most engineering books satisfy their reader's curiosity with the statement that 300 grains is the limit, while actually many boilers are being operated successfully with a concentration of 2,000 grains of soluble salts per gallon. There are two reasons for blowing down to prevent priming and foaming and to reduce scale formation by blowing off the sludge collected. In plants where water softeners are in use, the prevention of priming is the only reason, since with proper treatment and proper filtering, only a relatively small amount of non-soluble matter will be found in the boiler water.

How often and how much water should be blown from a boiler has been largely a matter of guesswork. Limits of concentration have been placed from 100 to 300 grains of soluble salts per gallon, while boilers have actually operated with a concentration of 3,000 grains. The objects of determining concentration are made plain and an outline is given of three methods employed. One of these methods, depending upon a new instrument, the "Densimeter," is unusually simple and as accurate as necessary.

It is important to remember that the water in the boiler, disregarding matter that is in suspension or floating in it, is from the scale-forming viewpoint, more nearly pure than before it is fed to the boiler. Water fed to the boiler may contain 30 grains of calcium and magnesium sulphates, and 20 grains of calcium and magnesium bicarbonates, but this same water after heating in the boiler will contain only a few grains of calcium and magnesium sulphates and practically no carbonates in solution. This water, however, will contain all the foregoing impurities in suspension, in which form they will cause scale and priming. If, on the other hand, this water is treated previously, some of the impurities mentioned will be taken out before the water goes to the boiler and others will be converted over into a soluble form in which they could do no harm other than to cause priming. For this reason, in any plant where feed water is chemically treated, trouble may be experienced from priming or a larger amount of water than necessary may be blow off, with the result that more makeup water has to be treated.

Priming is objectionable from several standpoints, of which carrying over water to the engine cylinders where it interferes with proper lubrication, is the most common. When superheaters are used, it fouls them and eventually the deposited sandy material works itself into the cylinders and there does damage to valves, piston and cylinder sliding surfaces. The carrying over of large quantities of water at one time may cause the blowing out of a cylinder head, with the consequent danger to life and property. It also causes considerable damage to piston-rod packing and when turbines are used frequent priming is fatal to the blades.

The point at which priming occurs varies with different waters, different boilers and the rate at which boilers operate, but if the priming point is once determined and concentration is maintained just below that point little trouble will be experienced.

Priming is caused both by matter in suspension and matter in solution. It is easy to determine the amount of matter in solution, but the method for determining the matter in suspension, while not complicated, is a task more for the chemist than the boiler-room operator. Ordinarily, however, the amount of matter in solution can be used as an indication of the amount of matter in suspension. Boilers are operated with as great concentration as 3,000 grains per gallon without priming trouble. Usually, however, trouble will be experienced below this point. In a certain plant having a hot-water softener and horizontal water-tube boilers, an overload of 85 per cent can be maintained with a concentration of 2,000 grains per gallon and with steam 99 per cent dry leaving the boiler.

When water is not treated, the concentration figure necessarily must be lower, and when organic matter finds its way into the boiler, scum will form on the surface of the water and priming will increase out of all proportion to the concentration. In such a case surface skimmers should be used for taking off the scum.

From the scale-forming viewpoint, blowing off is ineffective. While the amount of scale-forming matter in the boiler is reduced, there is always sufficient left behind to do harm. Also, with the boilers generally in use and operated at customary ratings, it is quite improbable that the suspended matter has much chance to settle, and if so, only a small part of the total amount will be within the range of the blowoff opening. Tests made of water from a horizontal water-tube boiler before and after blowing down 3 in. by the gage glass, indicate a reduction of 28 per cent of suspended matter and 22 per cent of solids in solution. The only really effective way of reducing solids in suspension in a boiler to such an extent as to minimize scale forma-

tion would be to use a direct-connected filter through which the boiler water could circulate and which could be backwashed at frequent intervals without interrupting the service. With such a filter most solids in suspension in the water would be eliminated, and it would be possible to operate with high concentration, since matter in solution would be left to cause priming. As this matter in solution would be slight when chemicals are not used to convert non-solubles into solubles, the boiler could be operated for a long time without being blown down.

When a boiler gives off large amounts of steam with the water level at the proper point, it stands to reason that, owing to steam bubbles occupying water space, the amount of water will be less and the concentration greater, so that when the boilers are forced priming is not only liable, due to great agitation but also due to greater concentration.

From all of this it appears that determination of concentration of boiler water is necessary to prevent priming, waste of water, entrance into the boiler of a greater amount of scale-forming matter than is nonpreventable, and in plants where water is treated, to reduce to the minimum the amount of chemicals used.

Determining Concentration

Before determining concentration, it is important to obtain a representative sample of water from the boiler. To take the water from the water column is inadvisable, because its great body and the attached steam piping act as a condenser, so that the water in the column is pure condensed steam. Even after the column is blown down thoroughly, tests indicate erratic undependable results, so to obtain a representative sample, direct connection to the drum or water leg should be made.

Before drawing the sample notice should be taken of the amount of water in the boiler. This is difficult since the gage glass shows the height of the body of water, but does not show how much water is displaced by steam bubbles in the water, which varies with the steam output at that instant. Therefore, when the boiler is equipped with a steam-flow meter, care should be taken, when drawing the samples, to see that the readings of the flow meter and of the water column are always the same. If the boiler is not equipped with a steam-flow meter, the condition of the fire and the opening of the feed valve should be noticed, although both of these observations are liable to considerable error.

Three methods are employed to determine boiler water concentration. Figs. 1 to 3 illustrate the apparatus required.

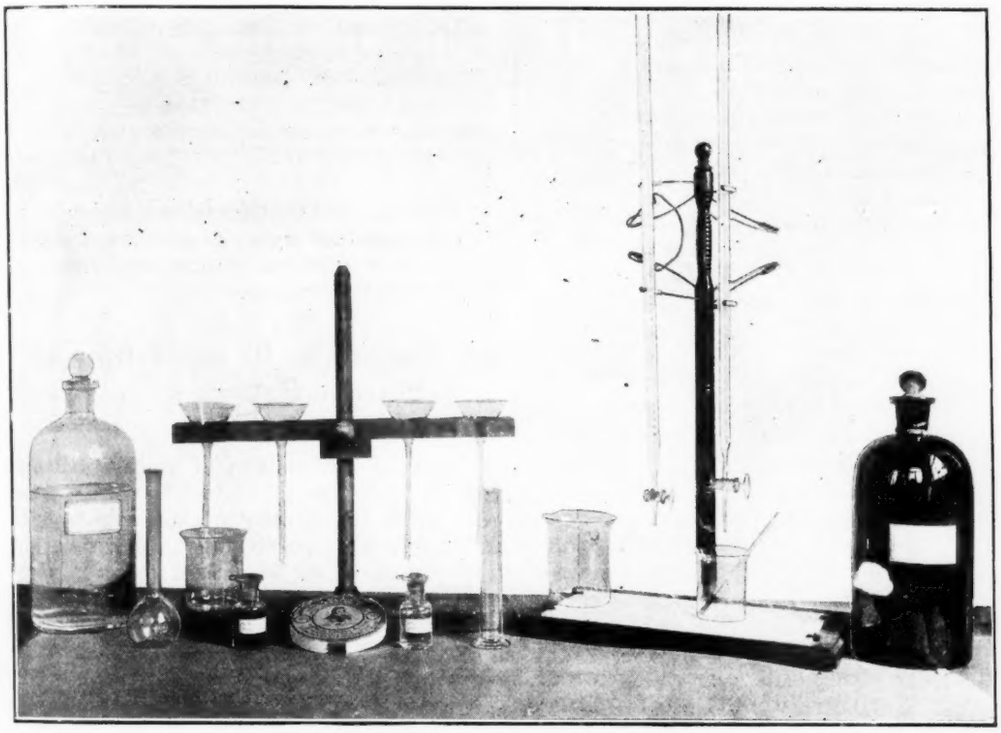

FIG. 1. EQUIPMENT FOR SODIUM CHLORIDE METHOD OF DETERMINING CONCENTRATION

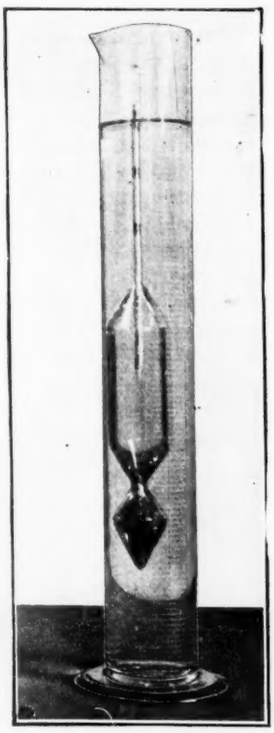

FIG. 2. HYDROMETER

Up to the present the method most generally used to determine concentration has been that in which the amount of sodium chloride in the boiler water is determined and compared with a carefully predetermined ratio of sodium chloride to solubles found in that particular water. Fig. 1 shows the necessary equipment, which consists of two burettes, a graduate, a filter stand, two beakers, one flask, filters, funnels and stirring rod. The chemicals required are one small bottle of potassium chromate, one small bottle of phenolphthalein, one bottle of one-twentieth normal sulphuric acid and one bottle of silver-nitrate solution containing 4.97 grams of silver nitrate per liter. The procedure is as follows:

1. Draw a representative sample of water from the boiler, settle the precipitate and cool.

2. With the graduate, measure out a 50 c.c. sample and pour it into one of the beakers.

3. Add one drop of phenolphthalein solution which will give the sample a pink color. Add the sulphuric-

acid solution from one of the burettes, drop by drop, while stirring continuously until the pink color just disappears.

4. Add to the sample two drops of potassium chromate and then titrate with the silver-nitrate solution from the other burette. During this process the water should be agitated continually by means of the stirring rod. When a slight reddish precipitate appears and remains the end point has been reached and the amount of silver nitrate solution used should be determined from the burette.

5. If the silver nitrate solution is of the strength previously given, each cubic centimeter used indicates 2 grains of sodium chloride per gallon.

6. The sodium chloride found should be compared with a standard ratio of solids in solution established by a chemist.

The hydrometer method, shown in Fig. 2, is seldom used. A specially made, large, sensitive hydrometer is required. Results closer than 100 grains per U. S. gallon cannot be expected. The difficulties are due to temperature stratifications, capilarity, viscosity and to the small range of graduations for a great range of concentration. Leaving accuracy aside the operation is simple. All that is necessary is to draw the sample, settle, or preferably filter immediately and cool to the temperature for which the hydrometer is graduated; then insert the hydrometer and take the reading. The hydrometer should be graduated in specific gravity terms of from 1.000 to 1.025, each division of 0.001 equaling 100 grains of concentration per gallon. The third method is made possible by the "Densimeter," an instrument recently invented and patented by E. C. Walker, a consulting engineer, of St. Louis. The method is the most convenient of all three and as accurate as is desirable. The instrument, consisting of a short piece of glass tubing, with a bulb at one end, properly sealed and calibrated, is shown at the bottom of the glass in Fig. 3. If a sample of cold distilled water is obtained and the densimeter immersed, it will float on top; if the sample is warmed, it will be noticed that at 100 deg. F. the densimeter will sink to the bottom; if a slight amount of salt is added at this point, it will again immediately float up, but this time at a different temperature, due to the presence of salt in the water. The point is that the temperature at which the densimeter changes position from the bottom to the top and the concentration of soluble salts in the water have a definite relation and that with the help of the curve shown in Fig. 4, if the temperature of the transition point is known, by reference to the curve the concentration in grains per gallon can be obtained.

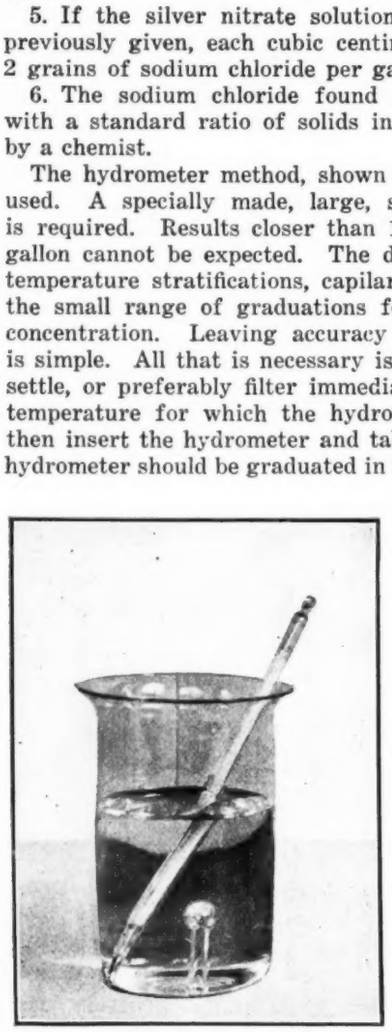

FIG. 3. OBTAINING CONCENTRATION WITH THE DENSIMETER

To determine boiler concentration with this method, draw the sample and insert the densimeter bulb while the water is still hot. The bulb will sink to the bottom. Stir the water with the thermometer until the bulb rises and read the temperature the instant the bulb touches the surface. From the chart the concentration may be read directly. A "floating temperature" of 100 deg. F. indicates that the water is distilled and pure. If the temperature is 150 deg. F. the water contains 1,130 grains of solubles per gallon.

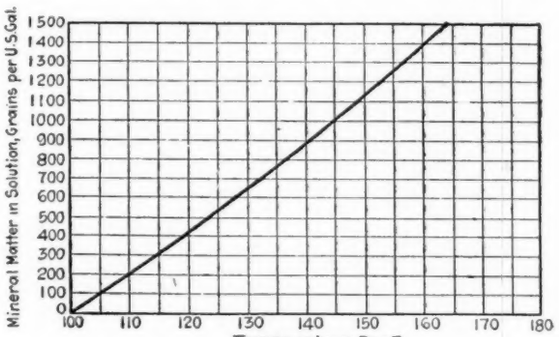

FIG. 4. DENSIMETER CURVE GIVING CONCENTRATION WHEN TEMPERATURE OF WATER IS KNOWN

Voltage Variations in Operation of Storage Batteries

By L. W. Webb

Generally speaking, the voltage of storage batteries varies during discharge from 2.15 to 1.76 volts, depending somewhat upon the density of the acid and the condition of the plates. Considering a cell discharging at an eight-hour rate, it will be noticed that as the discharge first starts the voltage drops instantly from about 2.17 volts to 2.15, due to the IR drop in the cell. From about 2.15 volts, the voltage falls rapidly in the first 30 or 40 minutes to about 2 volts; it then remains practically constant around 2 volts for about 4 hours; after which it once more falls off gradually for about 3½ hours until 1.76 volts is reached. The fall is more rapid at the last part of the discharge, and if this is continued longer, the voltage will drop so rapidly that very little output will be obtained. When the discharge point of 1.76 volts is reached, charging should immediately be started to prevent the sulphate on the plates becoming too hard (which it will do if allowed to stand discharged) and flaking and falling off when charge is started later. When the discharge current is stopped, the voltage of the cell on open circuit rises immediately to about 2.05 volts; and when the charging current is started, this jumps instantly to about 2.10 volts, due to the IR drop in the battery. From about 2.10 volts, the voltage increases rapidly for about 30 minutes to nearly 2.3 volts, and for the next 6½ hr. gradually to about 2.35, when it again increases rapidly up to about 2.5 to 2.6 volts at the end of the charge; this drops immediately to about 2.17 volts on open circuit as the charging current is stopped. The cycle of charge and discharge is plainly shown by the curves in Fig. 1. These are the average of results obtained on tests of various types of lead batteries on the market, and should by no means be taken as absolute values. The voltages at each point of the charge and discharge cycle may vary somewhat as

the cell gets older or the plates sulphated, etc. Also slight variations of voltage above or below these figures will result if acid of higher or lower specific gravity is used. The voltage also varies somewhat with the temperature and internal resistance of the cell. But, on the whole, the relation between the voltages at different stages of the cycle is that shown by the curves in Fig. 1 for an 8-hr. rate.

It will often be found that the cells cannot be made to come up to capacity after charge. In order to determine the trouble, a piece of cadmium inclosed in a perforated rubber sleeve is immersed in the electrolyte, and, with *normal* current flowing (*never on open circuit*), the voltage is read from the cadmium to the negative terminal, from the cadmium to the positive, and across the cell terminals. The sum of the first two readings must equal the third. Fig. 2 shows how the cadmium test is made and the results that should be obtained.

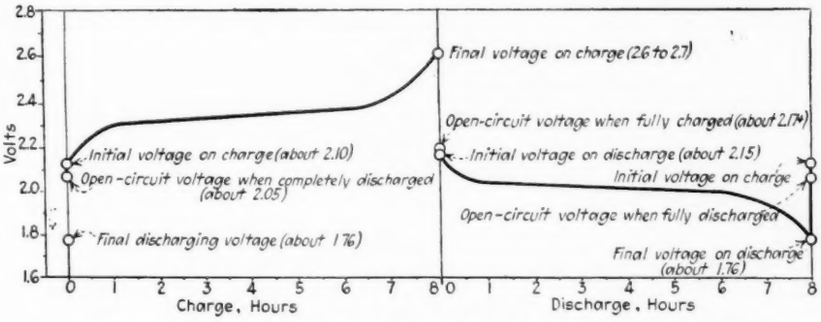
Volts
2.8
2.6
2.4
2.2
2.0
1.8
1.6
Final voltage on charge (2.6 to 2.7)
Open-circuit voltage when fully charged (about 2.14)
Initial voltage on charge (about 2.10)
Initial voltage on discharge (about 2.15)
Initial voltage on charge
Open-circuit voltage when completely discharged (about 2.05)
Open-circuit voltage when fully discharged
Final discharging voltage (about 1.76)
Final voltage on discharge (about 1.76)
0 1 2 3 4 5 6 7 8
Charge, Hours
0 1 2 3 4 5 6 7 8
Discharge, Hours

FIG. 1. CYCLE OF CHARGE AND DISCHARGE OF A BATTERY

Showing average values of voltage at different stages of charge and discharge at an 8-hour rate. These values are approximate and those encountered in practice may vary considerably from these; but the relation between voltages at different points of the cycle will remain closely as shown.

The positive plates always become fully charged in less time than the negative plates. It is, therefore, particularly important to watch the potential of the negative plate during the charge. No cell should be considered fully charged unless a positive potential of at least 0.05 is obtained between the negative plate and the cadmium. This may reach +0.20 volt in some cases, or any value between +0.05 and 0.20 volt, depending on the condition and design of the negative plate. This test determines the exact condition of each of the cell elements and just what condition of charge both negative and positive plates contain relative to each other. When the battery is fully charged, positive plate to cadmium shows about 2.35 volts and when discharged 2.04 volts. Negative to cadmium shows about +0.2 volt when charged and —0.28 when discharged.

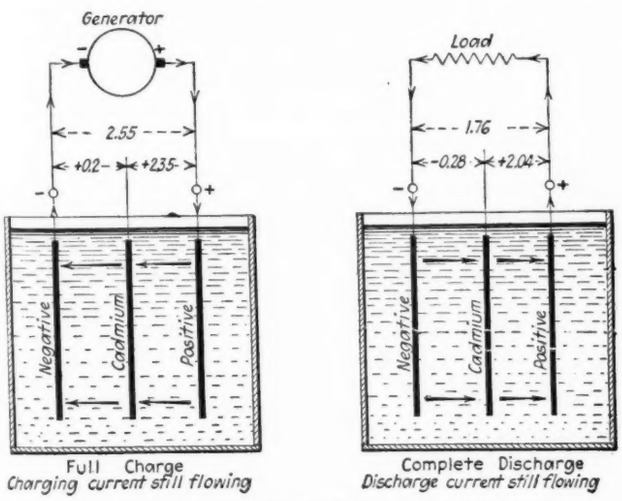

FIG. 2. CADMIUM TEST OF STORAGE BATTERY

Approximate readings that should be obtained between the battery electrodes and the cadmium electrode on full charge or complete discharge. Full rated current should be flowing through the battery while making these readings.

Cell voltage at end of full charge = 2.55 = 2.35 + 0.2

Cell voltage at end of complete discharge = 1.76 = 2.04 — 0.28.

When readings are obtained at the end of charge or discharge differing materially from those given, it is very easy to determine whether the negative or positive element is below capacity and steps can be taken to correct the same before any damage is done. It also tells when the useful life of the element is spent and when it is more economical to renew it than to continue to use it. In inclosed-type batteries these tests are very difficult to make properly, for unless experience and care are used, false readings will be obtained that are worse than none. But in large open-type station batteries they are of extreme importance and should be included as a part of the routine as well as voltage and gravity check readings.

The drop of voltage during discharge can also be explained by the fact that the internal resistance increases until at the end of discharge it is about four times more than at the beginning. The greatest increase occurs at the same time the greatest voltage drop occurs. This rapid increase of resistance indicates that sulphate is forming rapidly and clogging up the pores of the active material. On charge just the reverse occurs. In any cell the internal resistance depends on the amount of active material exposed, the distance apart of the two elements, the contact made with the supporting grids, the quantity, specific gravity and height of electrolyte in the cell, and the voltage characteristics are dependent on these properties. Polarization—that is, the accumulation of bubbles of gas on the elements—also causes increase in resistance and sets up a counter electromotive force which tends to cause a drop across cell terminals.

Potential transformer fuses of the ordinary type, consisting of an inclosed fusible wire, should be equipped with a series resistance capable of cutting down the current resulting from a dead short in the transformer to less than 100 amperes, preferably about 25 to 30. If this precaution is not followed, the metal in the wire is vaporized by the high current, and this vapor affords an easy path for the arc that often destroys the fuse holder and may spread to adjacent circuits. However, certain types of special fuses have to a greater or less extent the characteristics of circuit breakers and do not usually require series resistance. Among these can be counted the tetrachloride fuse, in which the link is submerged in liquid carbon tetrachloride. This substance is non-combustible and a good insulator, and the arc is extinguished almost instantly. These devices have proved, under careful oscillographic tests, capable of rupturing enormous currents that would have taxed large oil circuit breakers to their utmost.

Electric Elevator Machinery—Overspeed Governors

By M. A. MYERS
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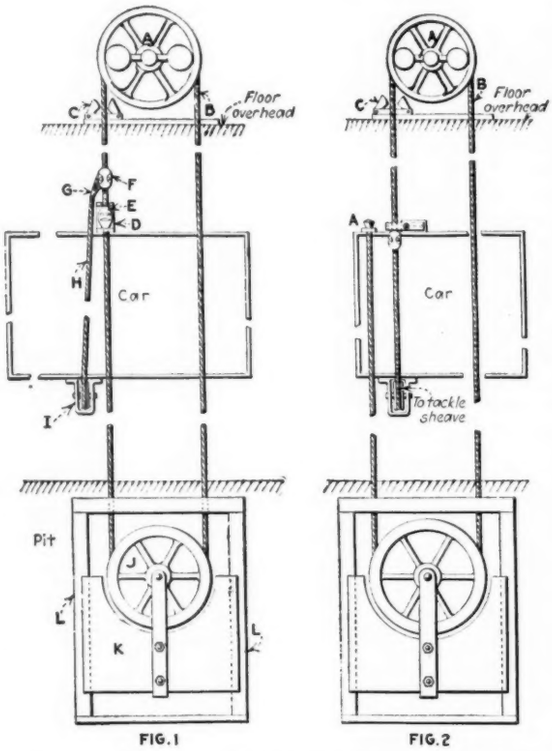
THE car safety is a device operating in conjunction with an overspeed governor and an endless cable, to bring the car to a stop by automatically clamping the car safety plank to the guide rails when an excessive speed is attained by the breaking of the hoisting cables or other reasons. Fig. 1 shows the general arrangement of the several parts incidental to a car safety. *A* represents the overspeed-governor sheave, with the cables gripping jaw *C*; *B* is the governor cable, made endless by the double-end socket *E*; *D* is what is known as the "releasing carrier," bolted to the top of the car; *J* is a weighted sheave located in the pit, *K* being the cast-iron weight or weights sliding in the guides *LL*. This device keeps a fixed tension on the endless cable and prevents slippage on the governor sheave. *H* is the tail cable leading over a sheave or pulley *I*, to the safety-device lever, drum or tackle as the case may be, and is fastened to the governor cable by means of an open socket *G* and a stop ball *F* clamped to the cable.

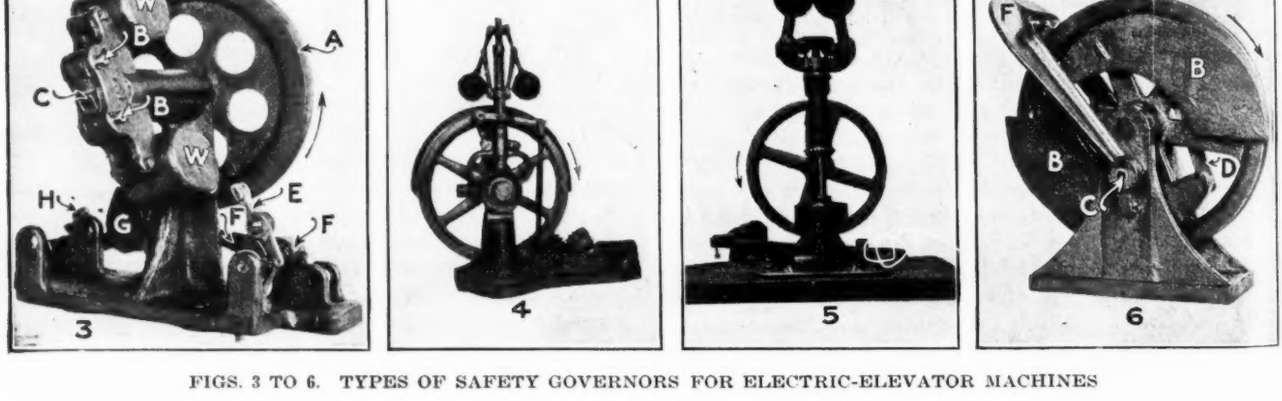


FIGS. 1 AND 2. ARRANGEMENTS OF SAFETY-GOVERNOR CABLES

The safety governor is a device designed to bring into action one or more cable-gripping jaws to arrest the motion of the governor cable when a car reaches a predetermined overspeed, ranging from 33 to 50 per cent above normal. The general principle does not differ from that of any other speed-controlling apparatus, the purpose being accomplished by means of weights (flyballs), arms and links held by spring tension or gravity or both against centrifugal action induced by the rotation of the balls. The roping arrangement for an A. B. See safety is shown in Fig. 2 and differs from that of Fig. 1 by having, instead of an endless cable, one end of the governor cable made fast to the car, as at *A*, Fig. 2. The cable from the dead end passes under the weighted sheave in the pit over the governor sheave and to the tackle arrangement on the bottom of the car for setting the safeties.

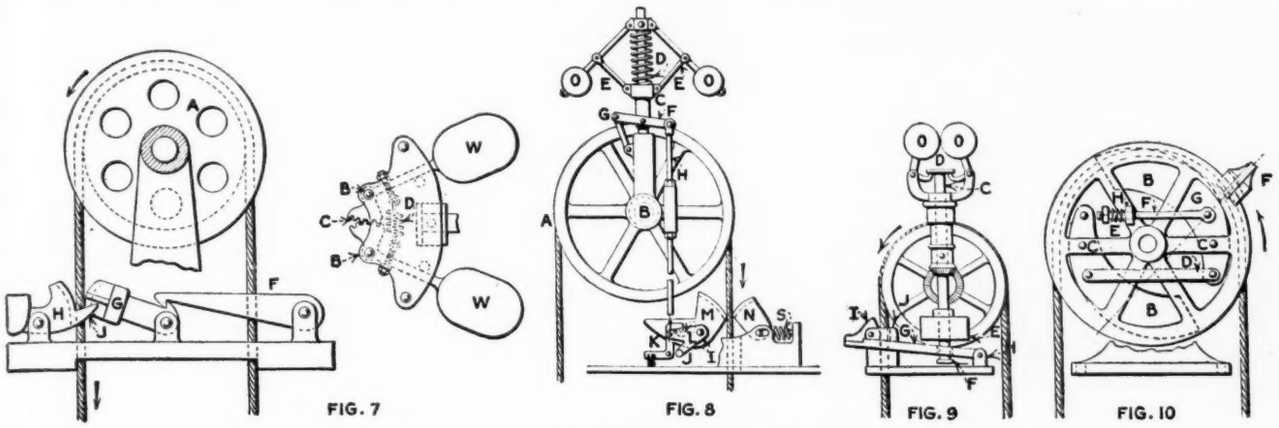
Four makes of safety governors are shown in Figs. 3, 4, 5 and 6. In Fig. 3, which is a Wheeler-McDowell governor, the sheave *A* rotates as shown for the down motion. The weighted arms *W*, pivoted at *B* and *B*, are synchronized by segmental gears at *C* (see Fig. 7), and are normally held from swinging apart by a tension spring *D* within the butterfly castings. The spring tension is regulated by wing-nuts on screw-eye shanks, which are sealed when finally adjusted. When the predetermined overspeed is attained, the "balls" throw out far enough to strike the free end of the lever *E*, rocking it on its pivot and lifting the latch arm *F*. This allows the weighted arm *G* to drop, carrying with it the overweighted free arm *H*, by means of the projecting finger *J*. The jaws of *G* and *H* are eccentrically rounded and cross-corrugated, and the instant they come in contact with the downward moving cable, the motion of the latter itself completes the clamping action, bringing the cable to a stop, thus applying the car safeties. To reset the governor it is only necessary to raise *G* until it latches.

In the Otis governor, Figs. 4 and 8, rotation is transmitted from the sheave *A* to the governor balls *O*, through bevel gears at *B*. As the balls throw outward, the sleeve *C* is drawn upward against the tension of



FIGS. 3 TO 6. TYPES OF SAFETY GOVERNORS FOR ELECTRIC-ELEVATOR MACHINES

spiral spring *D*, through the medium of the connecting links *E* and *E* (See Fig. 8). The sleeve carries with it the divided lever *F* pivoted at *G*. The upward motion is transmitted through the adjustable connecting rod *H* to the actuating lever *I*, a projecting finger *J* in turn pushing back the latch *K* that holds the jaw casting *M* in position by means of the projecting lug *L*. Once unlatched, *M* drops and the companion jaw *N*, synchronized with *M* by segmental gears, drops with it and contact is established with the cable in downward motion, which completes the clamping action. Jaw *N* is held in slotted holes in the frame against the pressure of spring *S*, which gives a certain amount of flexibility to the jaw to ease the gripping action on the cable.



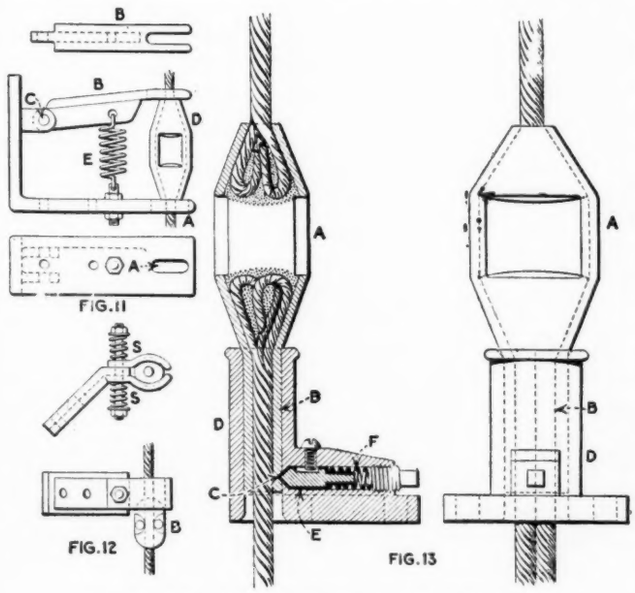
FIGS. 7 TO 10. DIAGRAMS OF GOVERNORS SHOWN IN FIGS. 3 TO 6 RESPECTIVELY

In the Gurney governor, Figs. 5 and 9, the balls *O* are rotated by gears as on the Otis governor. When the flyballs throw outward, the through rod *C* weighted by *E*, is lifted by means of the disk *D*. The tripping lever *G* pivoted at *H*, is then pulled upward by the collar F, its outer end rotating the gripping eccentric *I* on its pivot, clamping the governor rope between its jaw and the fixed jaw *J*, thus causing application of the car safeties.

Figs. 6 and 10 show a type of governor in which two flat curved weights *B* and *B* are pivoted, a short distance from their small ends, to the sheave spokes at *C* and *C*. The throw-out motion of the weights is synchronized by the cross-connecting rod *D*, Fig. 10, and the regulation is obtained by the compression spring *E* on the shank of the eye-bolt *F*, pivoted to one of the weights at *G*. The shank passes loosely through a projecting lug *H* on one of the sheave spokes and has an adjustment which is sealed when finally regulated. When the predetermined overspeed is reached, the weights throw out sufficiently to strike the heavy U-shaped casting *F*, carrying it upward toward the vertical center line. As this casting is pivoted eccentrically at *C*, Fig. 6, its extended jaw draws more deeply into the groove of the sheave as it approaches the vertical position. The motion of the cable completes the clamping action as soon as contact is established.

Motion is imparted to the governor by the releasing carrier, which is bolted to the top of the car or to the crosshead. This carrier overhangs the edge of the car, and holds in a flexible grasp that leg of the cable which passes through the gripping jaws, Figs. 1 and 2. The carrier has a spring arrangement that releases the governor rope when the motion of the latter is checked by the "setting" of the governor. The only connection then remaining between the governor rope and the car is through the tail rope *H*, Fig. 1, leading to the safety device proper, which is then actuated by the downward motion of the car.

Fig. 11 shows a simple releasing carrier. The governor cable passes through an elongated hole *A* in the cast-iron base and is held by the claw finger *B*, pivoted at *C*, clamping the double-end connector *D* with the aid of spring *E*. When the motion of the governor cable is arrested by the car's downward motion, finger *B* is moved upward on its pivot and the cable slips out of the slot. Another type of releasing carrier, shown in Fig. 13, makes use of a modified form of a double-end connector *A* with an extended flattened shank *B* provided with a notch *C*. This is held within the body of the cast-iron base *D* by means of a pointed trigger *E* under pressure of the spiral spring *F*. Both the governor cable *G* and the tailrope *H* are socketed in the lower basket of the modified connector as shown on the right. An A. B. See releasing carrier is shown in Fig. 12, in which the stop ball *B* is held beneath two curved jaws normally held closed by two spiral springs *S*. When the governor sets, the releasing carrier jaws are spread by the extra strain and the stop ball slips through.



FIGS. 11 TO 13. SAFETY-CABLE RELEASES

Pulverized Coal Versus Stoker Firing*

By F. P. COFFIN
Research Laboratory, General Electric Company

THE high efficiency obtainable with modern stokers has rendered the introduction of pulverized fuel for boiler firing less attractive, at first sight, than in the case of industrial furnaces. The development of the underfeed stoker has forestalled pulverized fuel in this field, so that the latter has a more difficult road to travel. Many engineers regard pulverized coal as the ideal fuel, but the additional machinery required for its preparation seems a handicap and renders it difficult to make the plant as compact. It is claimed, however, that large new plants can be equipped for the preparation and burning of pulverized fuel at less cost than for burning coal on stokers.

Mechanical stokers can handle much poorer grades of coal than can be burned satisfactorily by hand firing, and with less smoke. The underfeed types are capable of burning bituminous coal with considerable ash, especially if steam or air be injected upon the clinkers which fall against the bridge wall and side walls to prevent them from adhering to the bricks, but the output of the boiler is reduced in proportion to the leanness of the coal. Power-operated ash dumps are also effective for handling large amounts of ash and for breaking up clinkers. The percentage of combustible in the ash ranges from about 12 to over 40. In new installations this loss can be reduced to somewhere in the neighborhood of 7 to 9 per cent by the use of clinker grinders.

Some recent developments in burning pulverized coal have greatly stimulated interest in the methods of burning coal. Many engineers regard pulverized coal as the ideal fuel, but the additional machinery required for its preparation seems a handicap and renders it difficult to make the plant as compact. The underfeed mechanical stoker has much improved the efficiency of the boiler furnace, but it still has its limitations, especially when burning low grade fuel. With the development of efficient methods of handling and burning pulverized coal the power-station engineer has another method at his disposal for solving his problems.

Loss From Cinders Carried Up the Stack

One considerable source of loss in stoker installations is from cinders carried up the stack. This loss may average about 2½ per cent. In some large central stations cinder catchers are installed to prevent their accumulation in the neighborhood. The gases are passed under a hanging wall located above a tank filled with water, and their direction of travel is sharply reversed.

The limitations mentioned do not apply in the case of pulverized fuel. The furnace volume required for burning various grades of bituminous coal is substantially the same regardless of the calorific value of the fuel or of the percentage of ash. With any properly designed furnace the loss from combustible in the ash, or carried up the stack, is negligible.

The cost of pulverizing is an important factor, especially where the competition between the two methods of firing is close, as with high-grade coal.

When the cost of handling and firing coal on stokers is somewhat less than the cost of preparing and firing pulverized coal, the difference must be compensated for by economy and flexibility under operating conditions. After two years' experience with pulverized coal, the Milwaukee Electric Railway and Light Co. has adopted this fuel for its new Lakeside power station, which is to have an initial generating capacity of 40,000 kw. This has recently been placed in operation.

There are opportunities for improvement and simplification in the preparation of the fuel. Some of the advances now being made in the art may be effective in reducing the cost of preparation and conveying and will ultimately offset some of the limitations of pulverized fuel.

The most important advantage of pulverized fuel firing is its adaptability to a wider range of fuels than can be burned on stokers, notably the following: (1) Coals with a high content of ash, moisture or sulphur; (2) finely divided fuels like slack, culm and coals that have been subjected to cleaning processes; (3) highly coking coal, which cannot be readily burned on stokers; (4) semi-coke from low-temperature distillation processes. The same furnace is available for burning all grades of coal in pulverized form. Different types of stokers, on the other hand, are often required for burning different kinds of raw fuel. Low-volatile fuels are being burned in pulverized form. A preliminary test with pulverized semi-coke of 9 or 10 per cent volatile content indicates that it may be burned with as good results as bituminous coal.

Ease of Banking and Restarting Fires

Another important advantage is the facility and economy with which fires may be banked and the ease with which they may be restarted when steam is wanted suddenly. This makes pulverized fuel especially desirable in the following cases:

1. In steam reserve stations connected to water-power or other transmission systems.

2. For carrying peak loads in power systems where the base load is carried by units that it is desirable to operate continuously, as in the following cases: (a) High-efficiency prime movers already served by stoker-fired boilers; (b) boilers fired with blast-furnace gas or byproduct producer gas.

In the latter case gas and pulverized fuel may be burned either in the same boiler or in separate boilers.

Figs. 1 and 2 show a typical set of load curves for a central station in a large city. The winter peak, Fig. 1, due to the lighting load, runs up to 95,000 kw.

*From the author's contribution, "The Utilization of Coal on a Multiple-Products Basis," to R. F. Bacon and W. A. Hamon's forthcoming book "American Fuels."

and the various curves are selected for representative days under summer and winter conditions. The approximate annual load factor, figured from these curves, is 40 per cent. A horizontal line has been drawn at a load of 40,000 kw. to divide the load into what may be considered as base and peak loads.

On a system with these load characteristics the maximum peak above the base load is greater than the rather high limit set here for the latter, and the advantage of carrying this with pulverized fuel is increased by the low load factor and by the consequent opportunity for the elimination of banking losses. Moreover, only a small percentage of the total fuel supply need be pulverized.

A large central station having a load factor of about 37 per cent and equipped mainly with overfeed stokers showed an average consumption of 1.953 lb. of coal per kilowatt-hour for the year 1916. The overfeed stokers could be economically banked, the consumption being only 35 lb. per hour for each 5,000-sq.ft. boiler, but 1,500 lb. was required to bring the fire back into condition for operation. When a fire was allowed to go out, 1,000 lb. of coal was left on the grate and credited to the plant, while 6,000 lb. was required to light a boiler and bring it to steaming condition, ready to put on the line.

Allowing for these losses, it was estimated that the station economy, with constant load, would be 1.71 lb. of coal per kilowatt-hour, which corresponds to a reduction of 12.5 per cent in the coal consumption. It was also estimated that additional load could be taken on the existing plant, if it were evenly distributed over the 24 hours, at an economy of 1.56 lb. per kw.-hr., a reduction of 20 per cent. The coal consumed in banking fires and bringing them back into steaming condition was about 3.76 per cent of the annual consumption. Another large system has 15 stations feeding into it, 85 per cent of the total annual load being carried by four plants and 37.1 per cent by the most modern station. This station is equipped with underfeed stokers and operates at a load factor of 43.25 per cent, based on the maximum peak for the year. In this plant 0.81 per cent of the annual coal consumption is due to banking fires. The losses due to burning out and relighting fires, for cleaning and repairing boilers, bring these losses to approximately 1.5 per cent.

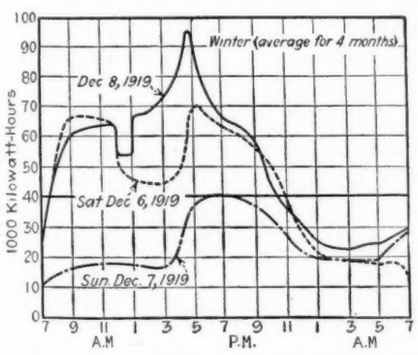


FIG. 1. WINTER LOAD CURVE FOR LARGE CENTRAL STATION

The banking losses for the entire system are as follows:

	Per Cent
Average annual banking losses	3.06
Maximum month (August)	3.60
Minimum month (December)	2.68
System load factor, based on maximum peak for the year	43.25
Fuel consumed for banking at any one station during any one month in the year:	
Minimum	0.33
Maximum	22.68

In the stations operated by a third large company the coal used for maintaining banked fires runs from 5.5 to 6.5 per cent of the total coal used. This is for a load factor of approximately 34 per cent. Underfeed stokers are used in the larger plants.

The systems referred to are in the vicinity of Boston and New York, and the fuel used is largely semi-bituminous coal from Virginia and West Virginia.

When coal is burned on stokers in stations that are used for stand-by service during several months out of the year, the consumption in banked fires is a considerable item of expense. This applies particularly in the case of steam reserve stations for hydro-electric transmission systems where steam must be kept up to maintain service in case of a failure of the transmission line. It would also apply where the base load is carried in one type of power station and the peak loads in another type of station. This will be the case when the base load is carried with byproduct producer gas and high-efficiency turbines, operating with high-pressure steam or with a binary vapor cycle, while the peak loads are carried in separate stations with solid fuel and ordinary steam pressures. Factory power plants present a third case, especially where most of the load occurs during a single working shift.

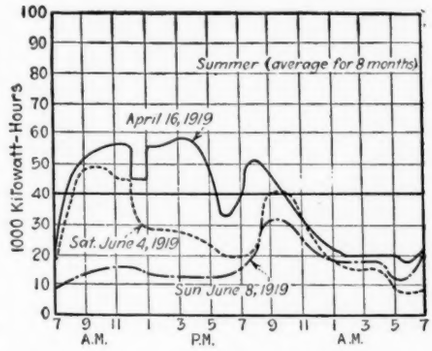


FIG. 2. SUMMER LOAD CURVE FOR LARGE CENTRAL STATION

Coal Burned During Banking Period

The amount of coal burned during banking periods varies with the service conditions. Many of the central stations that supply large cities have to provide light for a large number of office buildings when a thunderstorm suddenly approaches and dark clouds interrupt the daylight. This necessitates carrying banked fires in the summer season to nearly the same extent as in the winter. In fact, the highest peak load of the year is sometimes caused by summer thunderstorms.

Banked fires are carried at "hot bank" or "cold bank" according to the time available for getting a boiler on the line and under full load. A "hot bank," or "live bank," consists in carrying full steam pressure and having the fire in condition to get the boiler up to normal rating in from five to seven minutes. A "cold bank," or "dead bank," consists in burning only enough fuel to keep up a low steam pressure. On modern underfeed stokers the average coal consumption during banking is about as follows (the "time" is that required to bring the boiler up to normal rating):

Fire	Time, Minutes	Coal Consumption — Lb. per Hour * Average	Coal Consumption — Lb. per Hour * High Fig.	Percentage of Fuel at Full Load
Live bank	5 to 7	0.05	0.066	7.5 to 10.0
Dead bank		0.02	0.033	2.5 to 3.5
After 24 hours	11 to 15	....	.....	.....
After 43 hours	25			

* Per square foot of heating surface.

When a fire is run on "dead bank" for a considerable period, the accumulation of ash renders it impracticable to start up as rapidly as after a shorter period. The percentage consumed during banking is based on the fuel consumed when the boiler is operated at about 175

per cent of its normal rating, this being considered as full load. In carrying peak loads, the boiler may be forced to 250 or 300 per cent of its rating. An average figure for live and dead banking may be taken as 5 per cent of the full-load consumption.

In Figs. 1 and 2 the peak loads above the assumed base line of 40,000 kw. have a load factor of about 13 per cent, leaving a gross idleness factor of 87 per cent. If the boilers are forced to 250 per cent of rating while carrying the peaks, the net idleness factor may be taken as 60 per cent. It will not be necessary, however, to keep all boilers banked during this part of the time, so we shall assume that this factor may be reduced to 33 per cent. Then the ratio of the fuel consumed in banked fires to that used while carrying load will be $\frac{0.05 \times 0.33}{0.13} = 0.127$, or approximately as 1 to 8. Possibly this ratio will range from 10 to 15 or 20 per cent, according to the conditions.

Where pulverized fuel is used, steam has been held over night with only a small drop in pressure, and in the morning about four minutes' firing sufficed to bring the pressure up to normal. This indicates that it will be necessary to burn fuel only at intervals of several hours, to maintain steam pressure in continuous standby service comparable with live banking on stokers. The equivalent of dead banking conditions may be provided by less frequent firing, or a further economy may be effected if fuel be burned only under a single boiler in a battery. Steam pressure can be maintained in the remaining boilers by circulating either steam or hot water through them from the live boiler. This will eliminate furnace losses in all the boilers but one. A cold boiler may be brought up to full pressure in half an hour with pulverized coal, but it is hard on the boiler, owing to the rapid expansion of the metal. It is better practice to allow an hour and a half for heating up; hence the necessity for keeping the boilers hot where service is required in emergencies. It will then only be necessary to heat the brickwork. When banking with pulverized coal, the consumption should be considerably less than with stokers, as the draft may be shut off.

Anthracite is a more convenient fuel to store for long periods, at a steam reserve station, than bituminous coal, owing to the liability of the latter to ignite spontaneously, and this is also true with semi-coke. The traveling-grate type of stoker can burn only one size of anthracite efficiently (No. 3 buckwheat), while anthracite silt may be used in pulverized form.

Anthracite is under a disadvantage, as compared with bituminous coal, in heating up a cold boiler and furnace, owing to its slower ignition at low temperatures. This is equally true whether it be burned on stokers or in pulverized form. Where frequent or rapid starting is required, it may be advisable to provide an auxiliary supply of bituminous coal for this purpose. With semi-coke, on the other hand, it may be practicable to leave sufficient volatile matter in the fuel and to make it of such a structure that it will ignite more readily.

When operating with constantly varying loads, it is often difficult to control the combustion conditions to correspond with each change in load as promptly as is desirable. Pulverized coal is more responsive to delicate control than solid-fuel fires, and this introduces another factor in its favor, which should render it possible to attain better efficiency.

Devices for combustion control, both of indicating and of automatic types, are coming into more frequent use. These should improve the conditions when burning either solid or pulverized fuel, and especially in the case of the former, owing to the greater margin for improvement, in the case of stoker firing. In one instance, where automatic control has been used in connection with an underfeed stoker, it has been found practicable to operate with 25 per cent excess air. This is about as low a percentage as is practicable with pulverized coal for continuous operation.

The Investment Required

When operating with a good station-load factor, the investment required for a pulverized-coal installation is comparable with that required for a stoker installation. As the load factor becomes poorer, however, the pulverized-coal installation will cost less in proportion, provided the fuel requirements are sufficient to enable the preparation plant to operate at a good load factor. Sufficient storage capacity is installed in all stations for carrying the daily peak loads. Thus the fixed charges can be reduced on the pulverizing plant, while it is necessary to install stokers under all the boilers whether they operate at a high or at a poor load factor.

> The efficient utilization of our low-grade fuels is a matter of ever-increasing importance. The re-equipment of old boiler plants for burning pulverized coal may often be more easily accomplished than the installation of efficient stokers, even when good coal is burned.

When using stokers and carrying steady loads, the boiler is generally operated at an economical rating—that is, between 100 and 175 per cent. When steam is drawn from the same boiler for carrying peak loads, it is forced to 250 or 300 per cent of rating for limited periods. Under these conditions the efficiencies of both the boiler and furnace fall off considerably. The loss in furnace efficiency is due to incomplete combustion of the fuel owing to: (1) The loss of carbon monoxide with the flue gases; (2) the carrying of unburned coke cinders up to stack; (3) possibly an increased percentage of carbon rejected with the ash; (4) possibly an increased percentage of excess air is required for limiting furnace temperatures.

From the viewpoint of the investment in stokers it is obviously more economical to build furnaces of a suitable size to accommodate stokers of moderate capacity and to sacrifice efficiency when operating them at high rates of driving. With pulverized coal, on the other hand, the cost of the furnaces alone need be considered. It is more likely that the additional investment required for building the furnaces of sufficient size to insure complete combustion when carrying peak loads, should be offset by the saving in fuel that will result.

These considerations do not apply to stations or units operating largely on base loads. Favorable applications for pulverized fuel in carrying base loads should be where low-grade fuels are locally available at a price competitive with grades suitable for other methods.

Switch Requirements for Electric-Motor Control

By EDGAR P. SLACK
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THE National Electrical Code is a book of regulations issued by the National Board of Fire Underwriters for use in laying out electrical equipments and installing machines and circuits of almost every kind, in such a way as to reduce the fire risk. The Code is revised every two years, 1920 being the latest edition, and may be obtained at the National Board, 76 William St., New York City.

The Code must be concise, on account of the broad field covered, and some discussion of the more important rules may be of value in showing the reason for adopting them. One important set of rules deals with switches, fuses and wires for motors. The following remarks refer to switches, and the question of fuses and wires will be discussed later.

A switch in an electric circuit is like a valve in a pipe line; pulling the switch stops the flow of the electric current, just as shutting the valve stops the flow of water in the pipe. Switches are provided so that machines need not run except when needed, so that they may be isolated for adjustment or repair or be stopped in an emergency. The general regulations applying to motor switches do not cover the installation of electric cranes, which employ long, bare collector wires and are subject to special requirements. The Code requires in general that each motor "be controlled by a switch," excepting that certain types of circuit breakers and starting devices, as described later, may be used instead. The object of this rule is, of course, to allow each motor to be stopped, started and isolated for repair independently of all others. This rule is simply a statement of common sense and good practice. The switch must be "so designed as to indicate whether it is open or closed," so that a man can assure himself at a glance that the circuit is open in an emergency or if he is going to work on the motor.

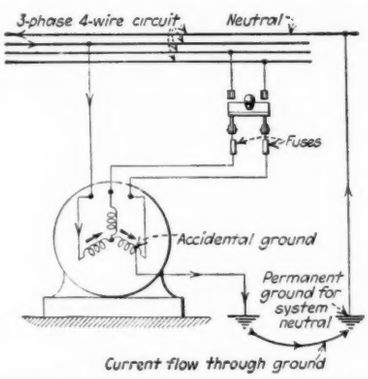


FIG. 1. WHY MOTOR SWITCHES SHOULD BREAK ALL WIRES
An accidental ground in the windings will ground the whole supply circuit through the motor.

"The switch and starting device must be located within sight of the motor," except by special permission. Motors during starting take a comparatively heavy current, and the object of this rule is to enable the operator to observe any overheating or fire that might result in the motor or starter. The rule also reduces the likelihood of injury to persons working on the machine. The rules require in general that "the opening of the switch will disconnect all of the wires." A direct-current or single-phase alternating-current motor therefore requires a two-pole switch, and a three-phase motor a three-pole switch. A two-phase motor if run three-wire would call for a three-pole switch, or if run four-wire would require a four-pole switch. If there was not a switch in each line, then in the event of an accidental ground there would always be the possibility of fire from overheating caused by current supplied through the unopened line. Fig. 1 shows a three-phase motor connected to a three-phase four-wire distributing circuit with grounded neutral, through a two-pole switch instead of a three-pole, the third terminal being tied directly to the line. In the case of an accidental ground on the windings, current will flow through the unopened line and the machine to the ground, as shown by the arrowheads, and would probably soon burn out the machine. An exception to this rule is made in the case of two-wire motors of ½ hp. or less on circuits where the voltage does not exceed 300, when single-pole switches may be used. This rule is of long standing, and is doubtless based on the small size and low voltage of the machine and the fact that, while small motors are by no means exempt from fires, the single-pole switch connection has proved generally satisfactory. If such small motors are supplied from a three-wire system, the switch should be placed in the two-wire branch circuit supplying the motor. It is preferable to connect the switch in the ungrounded line, so as to break all leakage paths to ground when the switch is open. These connections also apply to small single-phase motors on a three-wire single-phase circuit.

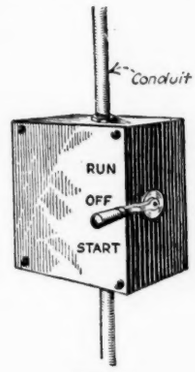


FIG. 2. ENCLOSED MOTOR-STARTING SWITCH

Various kinds of switches are used for controlling motors. Perhaps the most common is the knife switch, which has standard ratings of 30, 60 and 100 amperes and upward. The knife switch is simple and strong, but presents a large exposure of bare metal, with possibility of accidental contact. To overcome this disadvantage, inclosed or safety switches have been developed. They are generally of the knife-blade type in metal cases with external handles, as shown in Fig. 2. Many types have ingenious locks to prevent opening the case until the switch has been thrown off and all accessible parts inside "killed." These inclosed switches protect workmen from shocks and burns, protect the switch mechanically and reduce the fire hazard from metal chips or other objects causing a short-circuit. Snap-switches of the ordinary rotary or push-button types are frequently used for small

This is the first of a series of articles that will go into the whys and wherefores of electrical machinery, discuss underwriters' rules, and take up other things of interest to the man facing practical electrical problems.

motors, but are especially adapted for lighting circuits. Oil-break switches are also used on motor circuits. They are generally special forms of knife switches immersed in oil and completely inclosed; they can be made comparatively small in size, the oil reducing the necessary break distance.

Motor switches must conform to the general switch rules of the code covering location and mounting, which will be discussed more fully later.

Squirrel-cage motors on starting take a current several times the normal running current, which necessi-

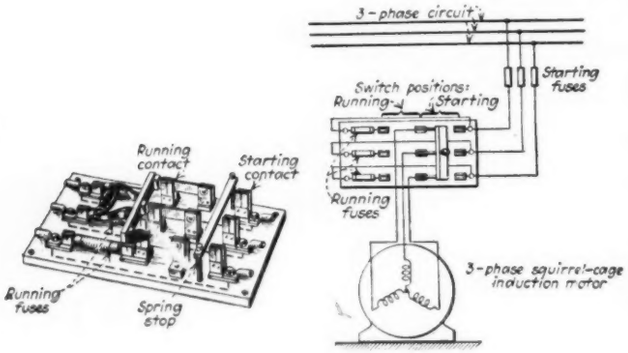


FIG. 3. TYPICAL THREE-PHASE MOTOR-STARTING SWITCH AND CONNECTIONS

The running fuses are shunted out during starting, leaving only the starting fuses in circuit. Note the bar and helical springs forming stop to prevent the switch being left in the starting position.

tates two sets of fuses—one large set of "starting" fuses to protect the line, and a smaller set of "running" fuses to protect the motor. With such machines a special double-throw switch is often used, which shunts the "running" fuses during the starting period. This type of switch is illustrated in Fig. 3. The Code requires that these double-throw switches shall be of such a type that they may remain in the "off" and "running" positions, but cannot be left in the "starting" position. The object is to prevent the motor from being left connected to the line with only the large "starting" fuses in circuit, as these would not protect it. The desired result is generally accomplished by small springs which throw the switch blades out of the "starting" contact clips if the handle is released while the switch is in the "starting" position. When starting the motor, it is therefore necessary to hold the switch closed against the pressure of the springs, until the motor has come up to speed and then throw it over to the running position. The connections of this motor switch are also given in Fig. 3.

"An automatic circuit breaker which disconnects all wires of the circuit may also serve as a switch," because it fulfills all the functions of a switch. The code also permits the omission of the switch "where the motor starter disconnects all wires of the circuit," because the starter really provides the switch, only in a different form, as in some remote-control starters with double-pole magnetic main switches. The switch cannot be omitted in the case of auto-starters, or starting compensators. The reason is that the presence of oil introduces an additional hazard due to the possibility of the oil catching fire; furthermore, the operating mechanism of the switch included in the starter is complicated and hidden from sight, and a separate switch is required by which the circuit can be positively interrupted if necessary.

Rebabbitting Engine Bearings

Almost every engineer at some time has faced the problem of renewing a main bearing that has had the babbitt liner ruined. It is advantageous to keep extra bearings on hand for such emergencies, but unfortunately, few plants carry replacement parts. When the situation arises, the engineer must determine the best way of rebabbitting and getting the unit back into service. In too many cases the old babbitt is melted out and a new lining run with a mandrel of the same diameter as the bearing. Often but not always the babbitt is scraped to a fair fit to the journal.

It has been generally found that when handled in the manner outlined, the babbitt fails to maintain an anchor to the bearing shell; it has a decided tendency to loosen and finally crack when in service. Usually, the particular make of babbitt is blamed, when almost invariably the methods followed in the babbitting process are at fault.

In preparing to run a new babbitt liner, the old metal should be carefully removed. Usually, it is necessary to heat the shell in order to remove the babbitt from the dovetail grooves. After the metal is removed, the shell should be thoroughly cleansed of any oil deposits by first washing with gasoline and then with lye water and wiping dry.

Muriatic acid is next placed in a porcelain or pottery vessel such as a small crock. Zinc scraps should be dropped into the acid until it is thoroughly "cut" or neutralized. The bearing shell is then brushed rather heavily with the cut acid. A blow-torch is played

FIG. 1. TINNING BEARING SHELL

against the side of the shell while the engineer rubs a solder stick all along the inner surface of the shell, as shown in Fig. 1. To insure a thorough tinning of the shell, sal ammoniac should be sprinkled over the surface as the coating of tin solder is rubbed into all the grooves. The tinning process insures a positive anchorage of the babbitt when run to the bearing shell. Without the preliminary tinning the babbitt on cooling appears to shrink away from the shell.

Before pouring the babbitt, it is necessary to procure a mandrel. If a more improved device is not at hand, a quite serviceable one can be made of a piece of pipe

and a companion flange, as outlined in Fig. 2 at *A*. The pipe should be at least one-eighth inch smaller in diameter than the shaft journal. A piece of asbestos should be placed on the flange and the two bearing shells clamped together with paper or brass shims between the halves and slipped over the mandrel. To insure against leakage, wet fireclay may be placed around the bottom edge of the shells.

Only a high grade of babbitt metal should be used on engine bearings. A cheap metal will always wear rapidly. In heating the babbitt in a ladle, two blowtorches impinging against the ladle are better than a

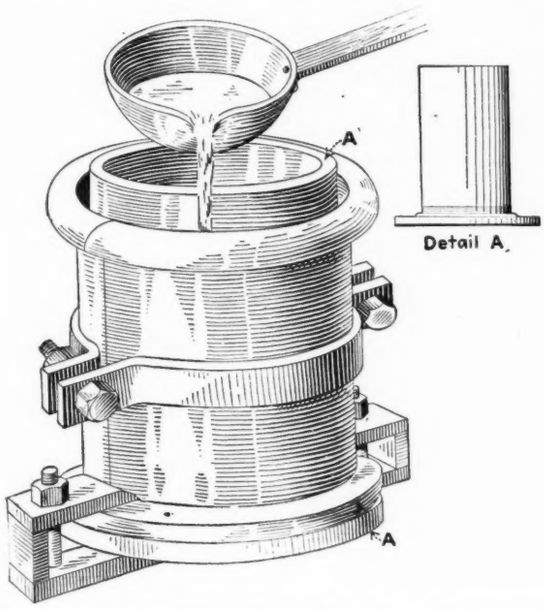


FIG. 2. BEARING SHELL READY FOR BABBITTING

coke or coal fire. The metal should not be hot enough to burn a pine splinter when the latter is thrust into the molten babbitt. If the stick chars but does not blaze up, the metal is about right for pouring.

After the bearing has been poured, it is never advisable to open the surface of the babbitt. Although this practice is quite usual, the peening does not make the babbitt anchor any better and often the hammering loosens the bond between the babbitt and shell.

Any bearing that is under high pressures such as occur with an engine bearing, should be bored to exact diameter. This is by no means difficult if a lathe or boring mill is at hand. Fig. 3 illustrates one method of boring the bearing. Here the shells are chucked on the lathe and the boring tool held in the toolpost. The lathe speed must be low or chattering will occur. Almost all bearings have a flat surface at the ends, and the bearing must be bored square with this edge. Care must be used in chucking the shells to get it in the correct position.

If the bearing is too heavy to be chucked, it can be clamped to the lathe carriage and a boring bar made of a piece of steel shafting with a cutting tool passing through the shaft and held fast by a setscrew. Often a drill press is called into service. In this case the shells are clamped on the press table and a boring tool made with two cutting edges to prevent side slippage of the spindle.

After boring, the shells should be separated and at the edges the babbitt should be cut away in order to provide a clearance which will enable the oil to enter between the bearing and shaft. All bearings on engines should be scraped to an exact fit to the journal. This is best done by coating the journal surface with Prussian blue or lampblack; in a pinch red lead thinned down with gasoline will do. A very light coating is applied and the shell placed on the journal and lightly rotated. When removed, the shell will be coated with the lampblack at those points where the babbitt is high. Scraping after repeated trials will finally cause the babbitt to bear evenly at all points. In cutting oilways in the babbitt, the grooves should not extend to the ends of the shell nor to the chamfer at the parting edges; this is to prevent a too rapid flow of oil out of the bearing.

With engines where the lower shell rests on a bored seat in the housing, the shell, including the babbitt, must be of the same thickness as the first shell when new. Consequently, in boring this must be measured and in scraping the babbitt must be cut away to give

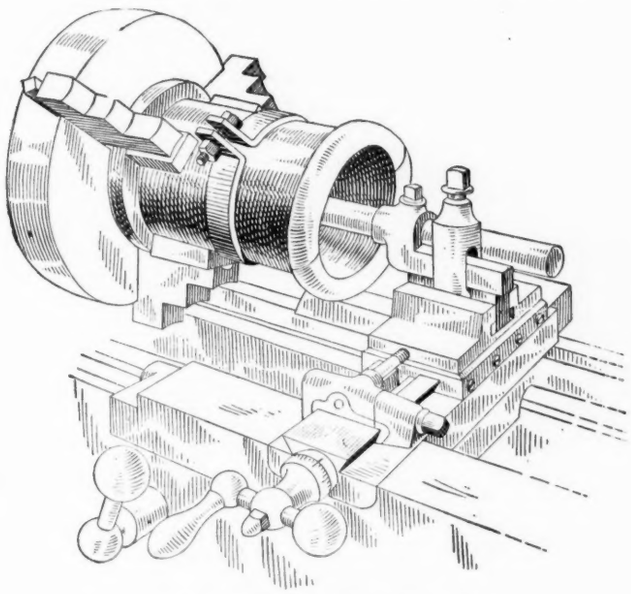


FIG. 3. BORING THE BEARING

this exact value. If the procedure outlined is followed, a bearing equal to the original one will result. A small amount of care and patience in doing the work will bring large returns in long bearing service.

The steam-oil engine has reached a commercial stage in England, according to *Marine Engineering*, which tells of the so-called "Still" engine, which is being developed by the Scotts Shipbuilding and Engineering Co. A single-cylinder experimental engine of this type has already been built, and it is planned to build another of the same design, except that it will have six cylinders. It is to develop about 2,000 b.hp. at 120 r.p.m. In design it is very much like an ordinary double-acting Desel, the lower head of the cylinder being used for steam and the upper half for oil. The steam is generated in the cylinder jackets and by the heat of the exhaust gases, at a pressure of about 120 lb. It is claimed that the fuel consumption of the experimental engine is 0.35 to 0.37 lb. per b.hp. The new engine is to be installed in a motor ship, and considerable interest will be felt in its performance.

Internal-Combustion Engines as Prime Movers for Refrigeration Plants

By W. H. MOTZ

THE development and use of the modern producer-gas power plant for ice-making and refrigerating plants has been due to two factors. In the first place the perfection of a practical method of manufacturing raw-water ice has made possible the utilization of the various methods of producing power in which steam is not used. In the second place, on account of the high cost of fuel the inherent characteristics of producer-gas power have demanded attention. When fuel was cheap, the efficiency of the power apparatus was not generally considered so important as when the cost of the fuel increased. Owing to these conditions it is advisable to select a prime mover that will produce the greatest refrigeration tonnage with the least expenditure of money and energy.

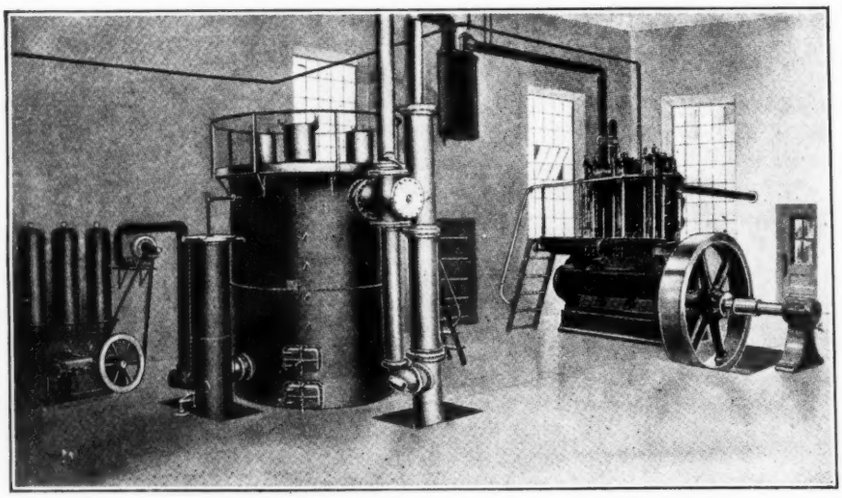


FIG. 1. GAS-PRODUCER PLANT

Ordinarily, it will be observed that the local conditions in the plant will determine what type of prime mover should be employed. Due consideration must be given to the kind of power available, the cost and kind of fuel, the supply of water and the type and location of the individual plants. A careful analysis of these local conditions will determine to a large extent the type of prime mover that should be employed. Under certain conditions it may be found that the steam plant would operate more satisfactorily and economically, or electric current may be purchased cheaply from a central station, which would make the use of an electric motor desirable. If natural or illuminating gas is available at a cost lower or equal to the cost of producer gas, and is constant in supply, these gases may be used advantageously. On the other hand, producer-gas power has been employed with desirable results in many ice-making and refrigeration plants. This type of prime mover is installed in all sizes of plants, a number of independent units being used in the larger plants.

A typical producer-gas power plant arranged to burn anthracite is illustrated by Fig. 1. Producers are made to operate on all kinds of coal. Coke, charcoal, semi-anthracite and anthracite have been used extensively in the past. At present, however, economic conditions generally make it expedient to use the lower grades of bituminous coal and lignite, although in any case more desirable results are obtained by using the best grades of the various kinds of fuels. The producer-gas engine may be directly connected or belted to any type of ammonia compressor. Generally speaking, the continuity of the service is good, since only low pressures are used in the system and its operation is simple. By giving all parts of the plant proper supervision and attention, this type of prime mover becomes very dependable and will render continuous service. The economy of the plant is very high, owing to the inherent characteristics of the system. Fig. 2 gives the fuel consumption in pounds of coal per brake-horsepower per hour delivered by the engines under varying load conditions. This chart is based on a heating value not less than 12,500 B.t.u. per pound for anthracite and not less than 10,000 B.t.u. for bituminous coal. The average efficiency of the producer is approximately 80 per cent; that is, a pound of coal having a heating value of 12,500 B.t.u. will be converted into available gas with a total heating value of 12,500 × 0.80 = 10,000 B.t.u. The general economies of producer-gas-engine refrigeration plants are shown by Fig. 3.

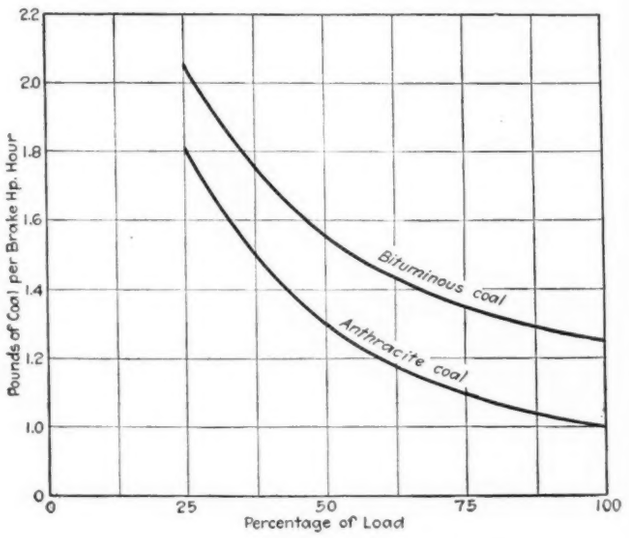


FIG. 2. ECONOMY OF PRODUCER-GAS-ENGINE PLANT

The cost of a ton of coal will vary with the locality of the plant and with the kind and grade of coal, of course. On the average this type of plant uses less than one-third of the amount of coal required by a steam plant under similar conditions. Therefore, the fuel cost is low. The initial cost of the plant is not above that of a highly refined steam-driven plant. The cost of maintaining the plant in good mechanical condition has been, in a number of instances, comparatively high. This may be lowered by the employment of high-class engineers. The general design of the apparatus is being improved from time to time, which tends to reduce the maintenance costs.

The operation of a producer-gas-engine plant is not difficult, and it can be operated successfully by a steam-plant engineer. Less labor is required, since the coal consumption is small. The producers may be stoked and cleaned at comparatively long intervals of time. Ordinary care will prevent the formation of clinkers,

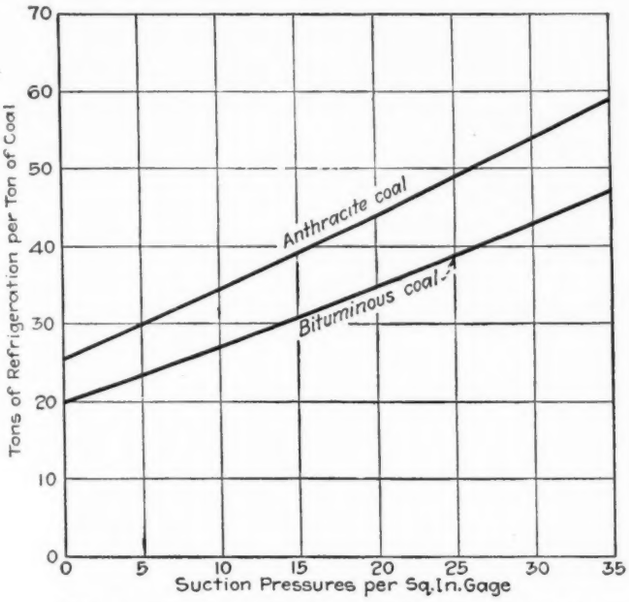


FIG. 3. REFRIGERATION PER TON OF COAL IN PRODUCER PLANT

etc. The plant on the whole is not as flexible as other forms of power. More or less difficulty may be experienced in starting and stopping the plant, and the load may be varied only within narrow limits. The average life of the producers will vary, of course, with many factors. They will last, ordinarily, approximately 10 to 15 years.

Oil Engines for Refrigerating Plants

Oil engines may be selected to drive refrigeration plants under certain local conditions. The type of the plant and its location will have an important bearing on the selection of the most suitable prime mover. It happens sometimes that the refrigeration plant and its auxiliary equipment are placed in such close quarters that only an electric motor would give efficient and desirable service. Steam may be required for other purposes around the plant, which would bring the steam-driven plant into favorable consideration.

The reliability of oil engines as prime movers may be increased by employing units that have 25 to 33⅓ per cent additional capacity above the actual requirements of the plants. Working at these lower percentages of full-load capacities is not so detrimental, since the fuel consumption, especially that of the Diesel type, is increased but slightly.

In plants where small engines are used, it is good policy to use a good grade of fuel oil in order to eliminate as much as possible the bad effects that would be produced by the employment of a low-grade fuel. However, in the larger plants, where greater quantities of

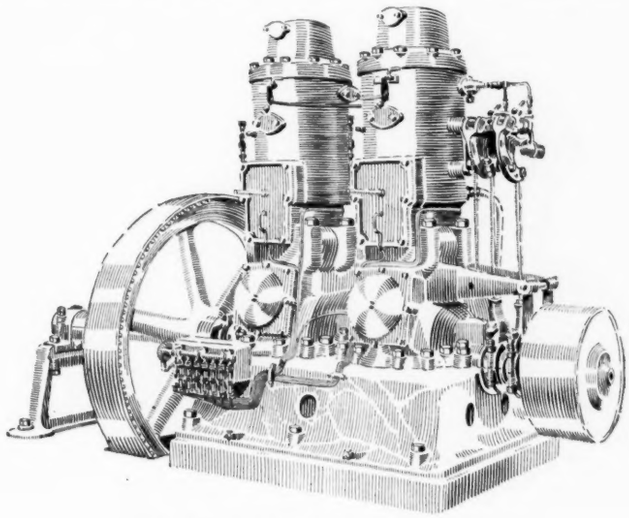


FIG. 4. SEMI-DIESEL OIL ENGINE

oil are consumed, it is advisable to use a lower-grade oil in order to reduce the cost of fuel.

The consumption of fuel oil by the Diesel engine of medium size is shown by Fig. 5 for various percentages of full-load capacity, as is the fuel consumption of the semi-Diesel type. These are the amounts that are guaranteed by the builders of oil engines. Fuel consumptions have been obtained in actual service appreciably below those indicated.

The relative efficiencies of the Diesel and semi-Diesel oil-engine plants as a means of producing refrigeration are indicated in Fig. 6. With respect to the amount of

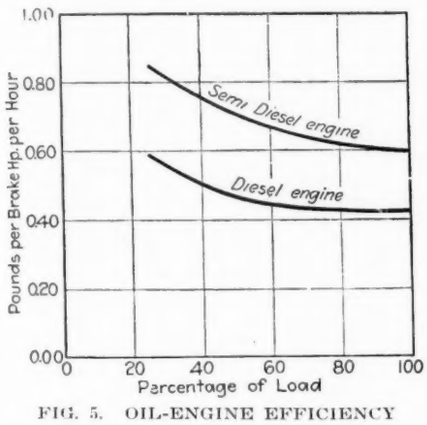


FIG. 5. OIL-ENGINE EFFICIENCY

refrigeration produced by the expenditure of a B.t.u. in heating value of fuel, the Diesel-engine driven plant is the most efficient type known.

Relative to the simplicity of operation it may be said that the semi-Diesel engines require only an intelligent attendant. It is only necessary that the operator keep these engines in good mechanical condition. He should, of course, understand the function of the engines thor-

oughly. On the other hand, the Diesel type requires an operator that is not only intelligent but also skilled. However, the Diesel type is not too complicated to be thoroughly understood and efficiently handled by the average plant operator, particularly if an effort is made to develop intelligent and skilled operating men in the plants.

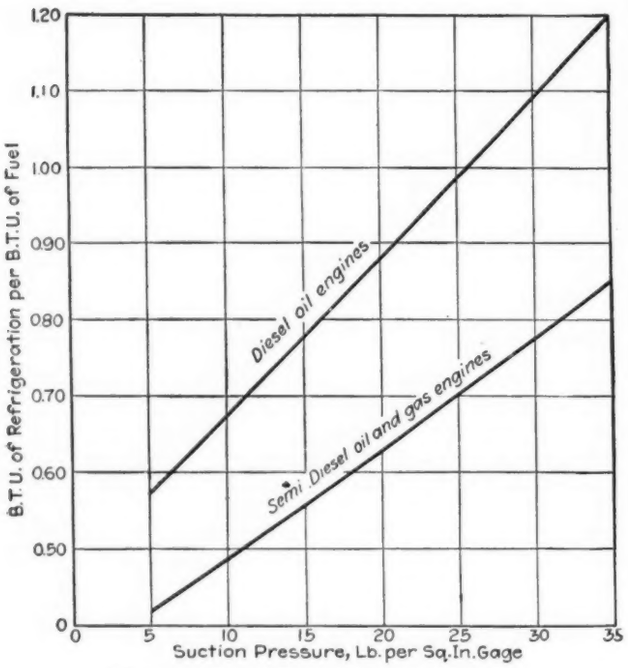


FIG. 6. EFFICIENCY OF OIL ENGINE IN REFRIGERATION PLANTS

Fiber and Some of Its Products

If one were to state where and how fiber is used about a power plant, there would be some difficulty in naming offhand but a comparatively few applications of its use, although it is largely employed as an insulator for electrical machinery, transformers, regulators and other apparatus.

The characteristics of fiber are interesting. It is tough and tenacious and possesses great strength. Its durability in use is exceptional, and time acts but to improve its peculiar qualities. It is light in weight and in this respect is perhaps equal to or exceeds any other material of like strength. The tensile strength of fiber is from 12,000 to 15,000 lb. per sq.in., its compressive strength varies from 38,000 to 42,000 lb. per sq.in., and its shearing strength is 9,000 to 13,000 lb. Its elastic limit may be variable, but tests show it to average 4,000 lb., and there is no permanent set even at the rupture point.

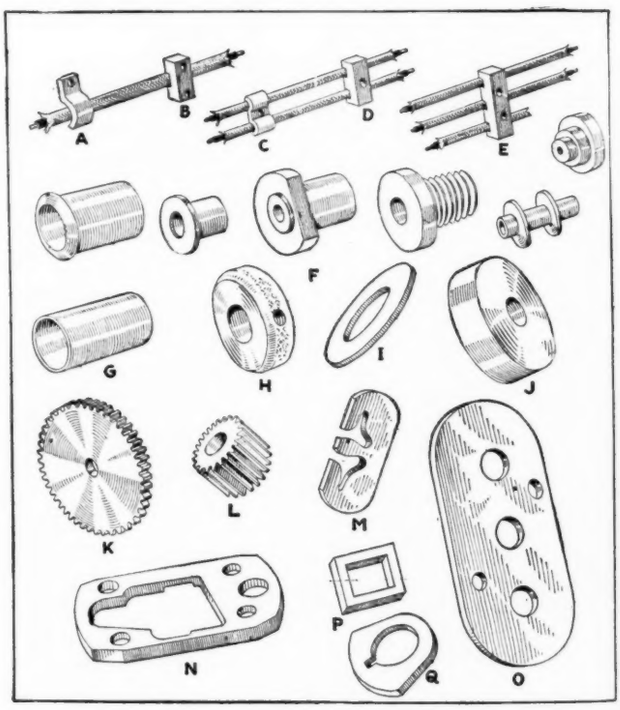
Fiber is not affected by mineral, vegetable or animal oils. Contact with or immersion in either, alcohol, turpentine, gasoline, naphtha, benzine or any ordinary solvent has no effect on it, nor will it absorb any of the foregoing fluids. Water will cause fiber to swell, but it resumes its shape when dried and is not deteriorated. Fiber will not melt or soften under the action of heat, and it requires a temperature of 650 deg. F. to cause charring or loss of elasticity. It can be sawed, planed, turned, drilled, punched, tapped, threaded and otherwise worked.

While at first the use of fiber in certain industries was limited to tubing, washers, cleats and other small articles for insulating purposes, at the present time telephones, radio instruments, dynamos, motors, electrical instruments of various type, toys and other articles of an electrical nature contain fiber parts. In short, fiber in some form or other will be found at practically every point from the equipment of the largest power house to the smallest device making use of electric current.

More recently there has been created demand for fiber packings in power plants, for joints of air compressors, oil-distributing systems, pumps and other power-plant equipment.

A recent visit to the plant of the Wilmington Fibre Specialty Co., Wilmington, Del., showed that hundreds of products for power-plant and other uses are made from fiber, a few of which are shown by the accompanying illustrations. For instance, *A* and *B* show two shapes of single-wire cleats, *C* and *D* double-wire cleats and *E* a three-wire cleat. Various-shaped bushings are shown by *F*. *G* is a piece of fiber tubing, *H* is a knurled handle, and *I* a fiber washer; even pump valves are made from fiber material, as shown by *J*.

Gears for various small machines and instruments are made from fiber, as indicated by *K* and *L*, together with the electric cord adjuster *M*, switch bases *N*, and conduit-box cover *O*, and various shapes of insulation such as shown by *P* and *Q*.



A FEW PRODUCTS MADE FROM FIBER

As fiber is made in sheets, rods and tubes, the engineer can easily produce special shapes that he does not require to purchase in quantity.

When installing and operating potential-transformer fuses of the tetrachloride type, it should be borne in mind that the vapors given off from the fuse after it has "blown" are poisonous, and proper ventilation should be afforded to carry off these vapors.

Welding a Hydro-Electric Generator Shaft

THE shaft of a vertical hydro-electric generator unit operated by the Bangor Railway & Electric Co., Bangor, Me., recently became fractured. The damaged member supported the rotor of a vertical water-power unit hung from a thrust bearing at the top. The fracture was believed to be due chiefly to the fact that the thickness of the upper member of the thrust bearing was too small, allowing the shaft too much play of an oscillating nature. The break occurred through the threaded portion, 5 in. in diameter, which engaged a nut for holding the upper member of the thrust bearing rigidly to the shaft. The trouble was probably the result of faulty design of the bearing, all the weight of the revolving parts of the unit being hung from the nut screwed onto the shaft. The periodic bending stresses produced by the oscillations of the rotor were in this way thrown directly on the threaded portion, that is, on the weakest part of the whole shaft. As shown in Fig. 1, there is a taper about 4 in. long between the lower portion of the shaft and the 5-in.-diameter portion in the end of which the break occurred.

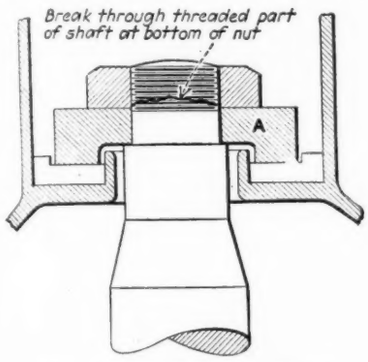


FIG. 1. CROSS-SECTION OF STEP BEARING

Showing location of fracture in generator shaft.

In repairing the shaft it was removed from the generator. Instead of attempting to weld the short end back in place, the tapered part of the shaft was machined farther back in order to obtain sufficient room between the tapered portion of the shaft and the under side of the bearing housing, thus obviating the necessity of removing the collar of the weld. The primary object of the collar on any thermit weld, it may be explained, is to obtain perfect fusion between the metal of the weld and the external fiber of the parts welded. At the same time if it be unnecessary to remove it for clearance purposes, it is desirable to allow the collar to remain, as it acts as an excellent reinforcement.

It was decided, while making the repairs, to change the design of the thrust bearing. After machining back the tapered shaft, a larger-diameter billet was thermit-welded on, as shown in Fig. 2. This was subsequently machined so as to permit the use of a heavier upper part of the thrust bearing, and a slip ring in a groove in the shaft to be substituted for the nut. The slip ring and groove were so designed as to take the full weight of the rotor, and yet allow the shaft sufficient freedom to allow it to adjust itself to any vibratory motion of the unit. In this way the periodic bending stresses that had caused the break were eliminated. In other words, the manner of making the repair made it possible to redesign the apparently improperly designed thrust bearing so as to make it stronger.

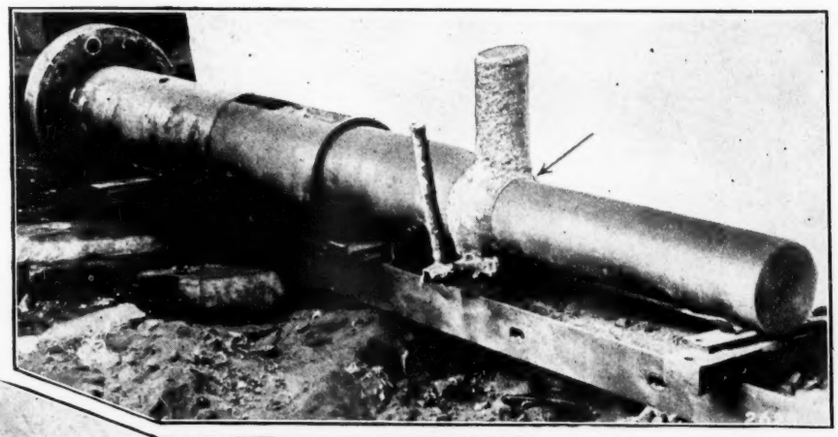


FIG. 2. THERMIT WELD MADE ON SHAFT

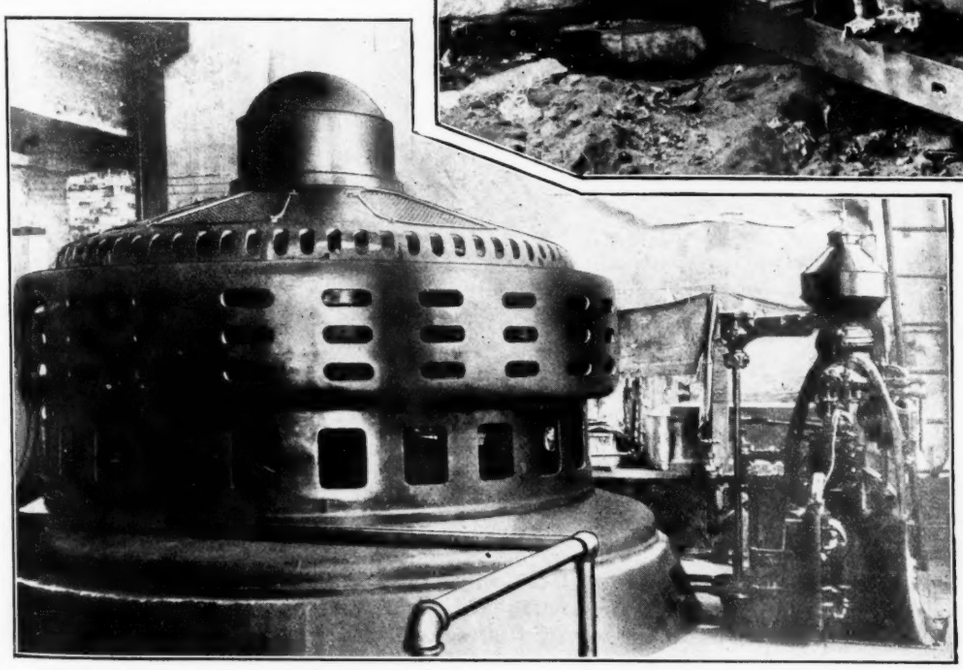


FIG. 3. SHOWING THE GENERATOR IN OPERATION AFTER WELDING

All potential transformers for uses with instruments should be provided with fuses in each of their primary leads, in order to protect the power circuit from possible short-circuits in the transformer windings.

Largest Traveling Screens Installed at Cincinnati

WHEN the Union Gas and Electric Co., of Cincinnati, recently completed the installation of sixteen 91-ft. traveling water screens, with a screening capacity of over 200,000 gal. per min., the largest installation of its kind in the world was placed in service. The screens are located in an enormous intake well 60 ft. in diameter and 86 ft. deep, situated in the center of the turbine room. They are arranged in "V" formation with eight screens on each side, set in double rows of four. The condensers of three 30,000-kw. (maximum rating) turbo-generators are supplied with the water passing through the screens and approximately 135,000 gal. per min. is being used at the present time.

From the description of the West End Plant containing these units, which appeared in the Sept. 3, 1918 issue of *Power*, it may be remembered that five wells were sunk below the turbine-room floor. A center intake well containing the screens, a condenser well on either side for two units each, and a discharge well between each condenser well and the intake, were provided. Tunnels from the river run into the intake well, and the water is delivered in opposing directions to a condenser well on either side arranged to serve two units. After passing through the condensers, the water flows to the discharge wells and thence through tunnels to the river downstream from the intake.

As explained in that article, each condenser well is 68 ft. in diameter inside and 84 ft. deep from the basement floor. The condensing equipment for the first two units is located at the bottom of the west well, the other well being provided for the third and fourth units. From the basement floor the intake well is 86 ft. deep and 60 ft. in diameter inside. The bottom is approximately 16 ft. lower than the stream's low-water mark, so that there should always be a plentiful supply of water under all river conditions. In the well a heavy bar-iron grill was inserted to remove the coarser débris floating in the river, and behind the grill traveling screens were provided to remove any rubbish that might pass through the grill. A set of stationary screens was provided to supplement the traveling screens when necessary. The intake tunnel leading into the bottom of the well is 163 ft. long, 10 ft. wide and 25 ft. high, with reinforced-concrete walls 3 ft. 6 in. thick. From the intake tunnel the cooling water passes through the screens into 54-in. suction pipes extending through the floor of the condenser well to the circulating pumps. From the condensers the cooling water is discharged through 54-in. pipes to the discharge wells and from there back into the river through the discharge tunnels. The entire cooling-water system from the intake well to the exit of the discharge tunnel into the river is a closed siphon, so that it is only necessary for the circulating pumps to overcome the friction in the piping and the condensers.

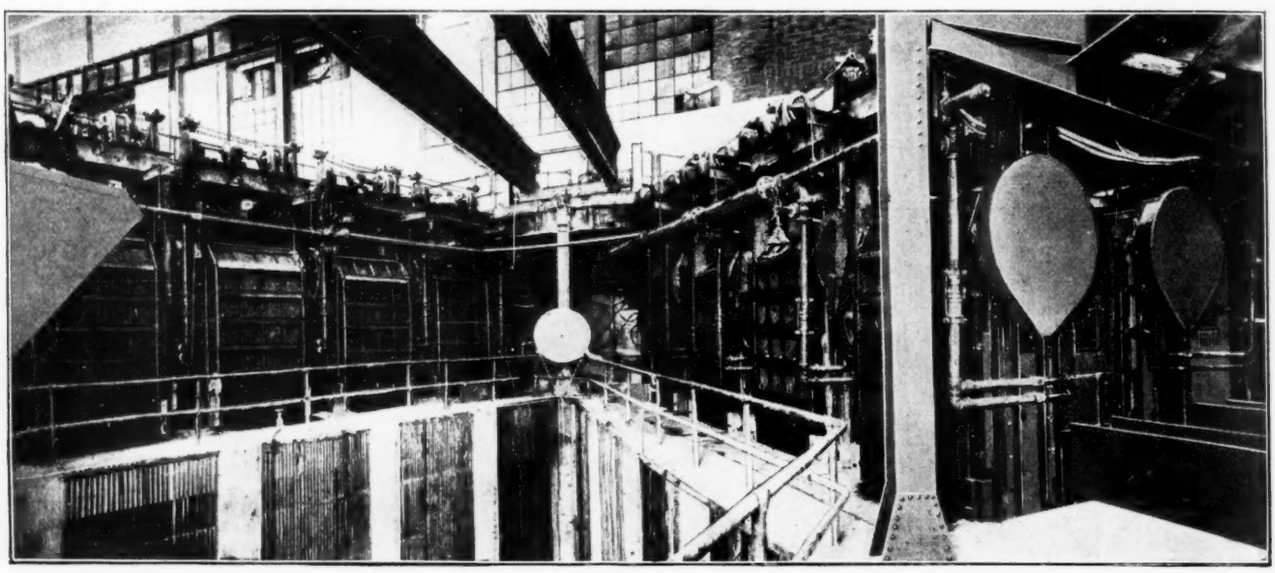


FIG. 1. OPERATING FLOOR AROUND WELL

In the initial installation an attempt was made to meet the great rise and fall in the river with two traveling screens 51 ft. long, mounted on slides. Steel baffle plates were then slipped into place to cut off that section of the intake not protected by the screens. The installation operated satisfactorily so far as the rise and fall of the river was concerned, but the large amount of refuse and non-floating débris which collected at the bottom of the intake necessitated too much labor in its removal. The larger screens were then decided upon.

With the present installation most of the débris and foreign matter are brought up by the traveling screens and such silt as deposits at the bottom of the well is removed by a grab-bucket suspended from a crane shown in Fig. 1.

While functioning collectively, each screen is a self-

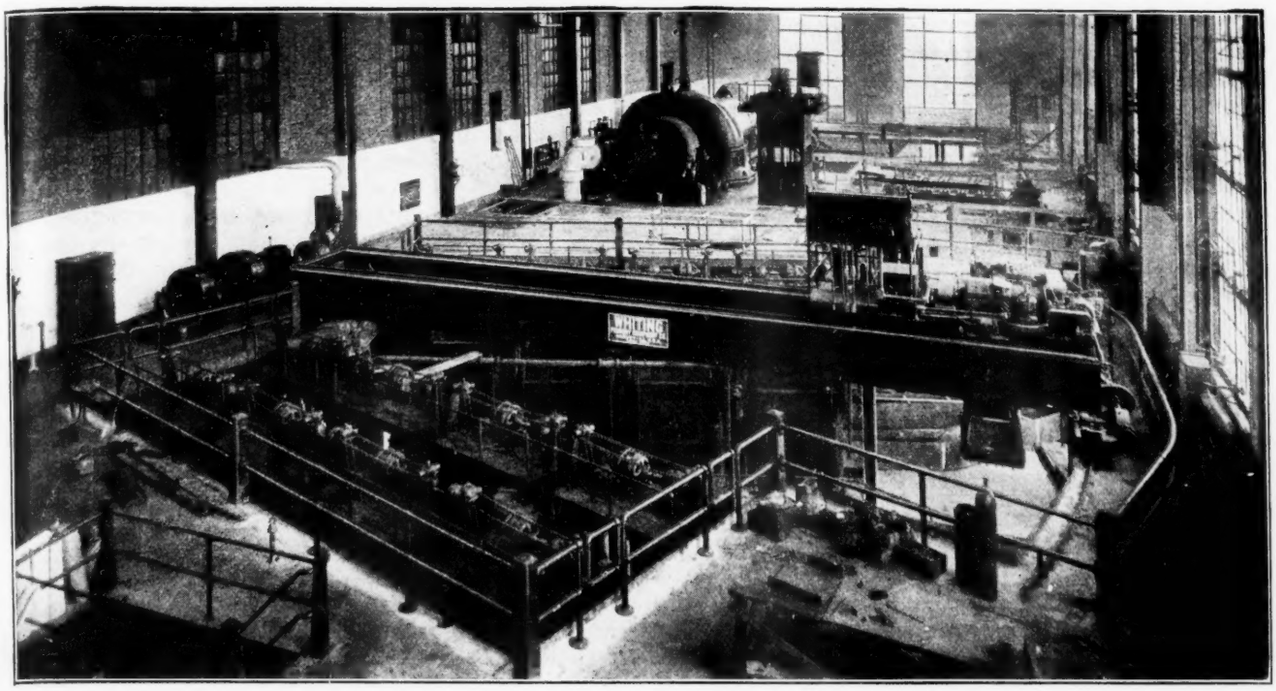


FIG. 2. GENERAL OVERHEAD VIEW OF SCREENS

contained unit operated by an independent 7½-hp. motor. For each unit 131 wire screen baskets, each 5 ft. 8 in. wide and 18 in. long, were required. These are mounted on two strands of bronze-bushed steel roller chain operating over head and foot sprockets at 91-ft. centers. The screen is No. 10 galvanized wire cloth with ⅜-in. openings. To prevent any débris or foreign matter from getting by between or around the baskets, special overlapping lips and guards are provided. Each basket is equipped with a cup or trough for catching the heavier bits of débris and preventing their return to the intake water when they do not cling to the screen proper.

As the twigs, grass, fish, leaves and other matter are brought up by the screens, they are carried over the top and deposited in a refuse trough just as the baskets are starting their downward trip. A powerful spray directed through the screen at this point dislodges all material tending to cling to the baskets.

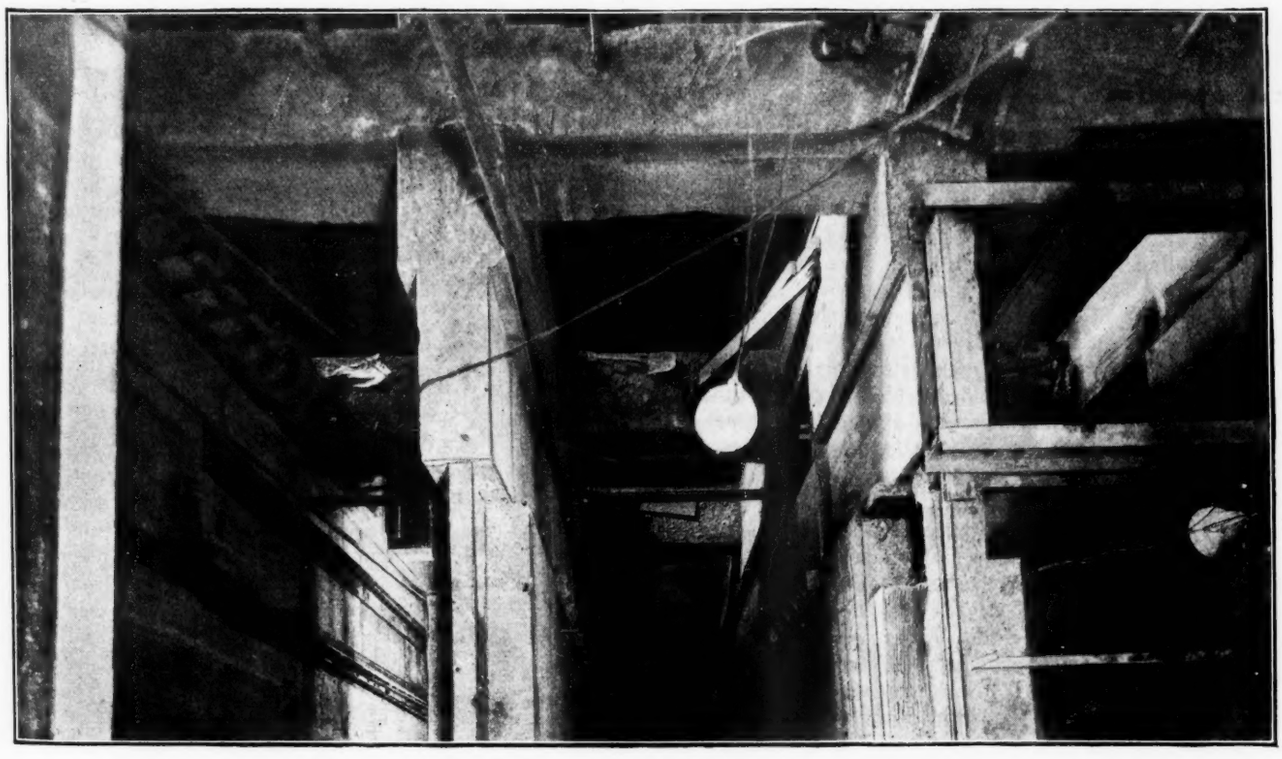


FIG. 3. LOOKING DOWN INTO THREE SCREEN COMPARTMENTS

To the annual wild rampages of the Ohio River must go the credit for this record-breaking installation. Few streams in the country carry as much foreign matter and with such speed as does the Ohio during spring flood periods. The rise of the river is extremely rapid at times, and records show that the maximum rise has been as much as 70 ft. at Cincinnati. This is responsible for the extreme length and great capacity of the screens.

Operation of the screens is a simple matter. After they are put in motion and the water spray started, practically no attention is required. When necessary they can be operated continuously day and night, so that the condenser water is always dependably clean. When conditions are favorable and not much refuse is coming down the river, they are placed in motion only occasionally, a few minutes each time being found sufficient.

Sargent & Lundy, of Chicago, were the engineers on this work for the Union Gas and Electric Co., and the screens were furnished by the Chain Belt Co., of Milwaukee.

A Recorder of Both Combustible Gases and Co_2

By This Means the Fireman Is Not Misled by High CO_2 at the Expense of Efficiency Due to the Presence of Combustible Gases

By ROLAND MOELLER

THE accompanying flue-gas-recorder charts represent a recent development in combustion control. They were produced in a series of three tests of the same boiler furnace in the order indicated. They differ, both in construction and in the message that they convey, from the charts produced by ordinary automatic gas analyzing and recording instruments. The clear spaces at the bottom represent CO_2 in the flue gases, and the lightly shaded portions between the white and the heavily shaded areas indicate combustible gases.

The chart shown in Fig. 1 reveals, by the comparatively low CO_2, too much air. The second, Fig. 3, taken after the setting had been repaired, reveals, by the continual presence of combustible gases, improper firing and poor draft regulation. Fig. 5 is a record showing maximum economy in fuel consumption as demonstrated by high CO_2 and the nearly complete absence of combustible gases.

Loss in Combustible Gases Large

The percentage of CO_2 is a measure of the sensible heat lost in the flue gases; the percentage of combustible gases is a measure of the undeveloped heat of combustion. The heat of combustion represented by 1 per cent of combustible gases is far greater than the sensible heat carried away by the excess air corresponding to a change of 1 per cent in CO_2. Besides, the percentage of combustible gases usually increases much more rapidly once they begin to appear than does the corresponding percentage of CO_2, and the losses due to their presence are consequently serious.

When fuel is burned under a boiler, the greatest loss ordinarily is in the form of sensible heat carried up the chimney in the flue gases, but when it is attempted to reduce these sensible heat losses by decreasing the amount of air supplied, there is the danger of having unburnt combustible gases escape. The combined losses depend to a large extent on the skill and care of the fireman in handling the fire as well as in the regulation of drafts.

There is a critical point in the operation of a furnace where, when it is operating under its most economical conditions, a decrease in the air supply results in the escape of unconsumed combustible gases. An increase in the air supply results in unnecessary excess air in the flue gases. The percentage of CO_2 at which this critical point occurs not only varies in different furnaces, but varies from time to time in the same furnace, according to the load, the firing and the characteristics of the fuel. It is the point where the maximum percentage of CO_2 is obtained without the simultaneous appearance of combustible gases.

Continuous Analyses and Records Necessary

Only from simultaneous continuous analyses and records of both CO_2 and combustible gases is it possible to determine and avoid overstepping the critical point. With such information constantly before him the fireman can strive so to improve his methods of firing, the condition of his fire beds, draft regulations, etc., as to maintain the highest possible CO_2 without combustible gases, which is the condition of maximum efficiency.

Figs. 2, 4 and 6 show charts produced by an instrument recording CO_2 only. Fig. 2 was made simultaneously with Fig. 1, Fig. 3 with Fig. 4, and Fig. 5 with Fig. 6. Note that the CO_2 readings on the corresponding charts are practically identical.

Chart Fig. 1 was made without the fireman's knowledge. He had only the CO_2 record, Fig. 2, to guide him. His instructions not to exceed 11 per cent CO_2 were based on the results of a snap CO test, and engineers seeing record Fig. 2 might conclude that too much air was going through the furnace and that the air supply should be decreased to raise the CO_2. A glance at the record, Fig. 1, however, shows how incorrect such a mode of procedure of itself would have been.

Combustible Gases Accompany Excess Air

Chart, Fig. 1, shows uneconomical combustion due to unburned combustible gases in spite of the presence of too much air. Decreasing the air supply under such conditions would only have increased the amount of unburned combustible gases, and the waste due to this cause was already enormous. The revelation of this fact led at once to an investigation which resulted in the discovery that the presence of too much air in the flue was due to leakage in the boiler setting and not to the condition of the fuel bed.

Here we have a good illustration of one of the many conditions under which combustible gases—the result of incomplete combustion—occur simultaneously with a considerable excess of air in the products of combustion.

A record of CO_2 alone cannot reveal such wasteful conditions.

Records like Fig. 1, therefore, point the way toward improving combustion in a given furnace, not only by serving as a guide in firing and damper regulation, but also when improvements are desirable in the grates, combustion space, baffles, arches, wing-walls, dampers, settings, chimney, mechanical draft, or when other alterations or a reconstruction of the furnace are considered.

Referring to combustion control based on records of CO_2 only, a recent article[1] in *Power* entitled, "Fuel Economy and the Human Factor," contains the following significant remarks.

> The most glaring example of fallacious bonus schemes is, to the expert, that based on the percentage of CO_2 in the chimney gases. The CO_2 bonus may operate fairly for a short time, but when the boiler-room crew find out how to juggle with it, it will probably be unfair to the employer. The CO_2 record is but one link in a complete chain, and there are circumstances under which its indications are no guide at all to the thermal efficiency being obtained in the plant.

This author evidently knows that a fireman who has his wits about him can easily maintain a high percentage of CO_2 where this is the only guide, while the plant suffers huge losses, which only become evident through making an analysis to determine the unburnt combustible gases.

All the factors of efficiency of combustion ordinarily invisible must be measured and recorded. The Duplex Mono double recording instrument, by which these charts were produced, does this by measuring and recording not only CO_2, but also combustible gases. This instrument makes sensible-heat and combustible-gas losses visible to the fireman and also records them for the observation of the plant executive. No limit should be placed on how high the CO_2 should be kept by the fireman, provided he avoids combustible gases in the flue. Under this régime the fireman who maintains the highest average CO_2 record with the least evidence of combustible gases is the best man, provided, of course, that he carries his share of the load. With CO_2 records only, the most conscientious, efficient and economical fireman may have the worst record to show, while the unscrupulous, irresponsible fireman who knows all the tricks, may carry away the honors and do the least work.

Charts Figs. 4 and 5 clearly bear out the foregoing. They were made after the air leakage in the boiler setting had been stopped. In this second test, as in the first, the fireman was given only the CO_2 recorder to guide him. The resulting chart, Fig. 4 (showing CO_2 only) is a very nice record, one of which a fireman working with any instrument recording CO_2 only might

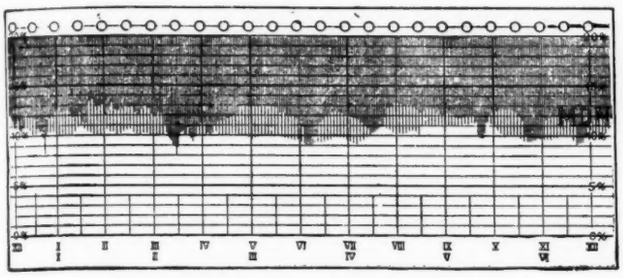


FIG. 1. LOW CO_2 AND TOO MUCH AIR

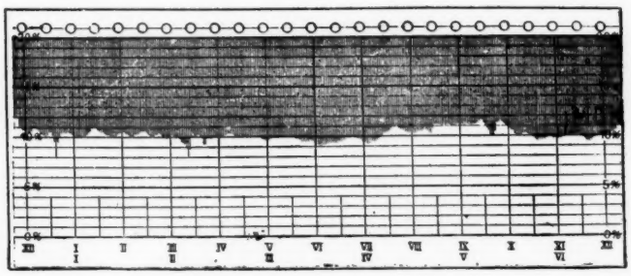


FIG. 2. CO_2 CHART CORRESPONDING WITH FIG. 1

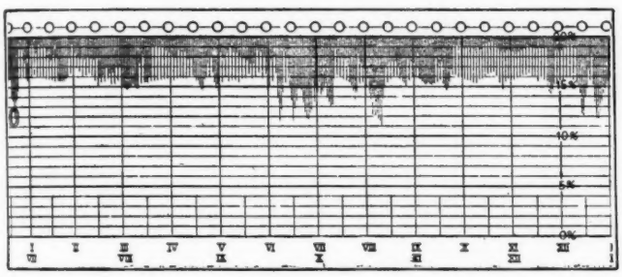


FIG. 3. SHOWING PRESENCE OF COMBUSTIBLE GASES

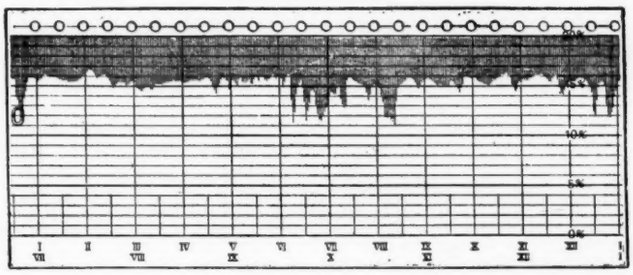


FIG. 4. CO_2 CHART CORRESPONDING WITH FIG. 3

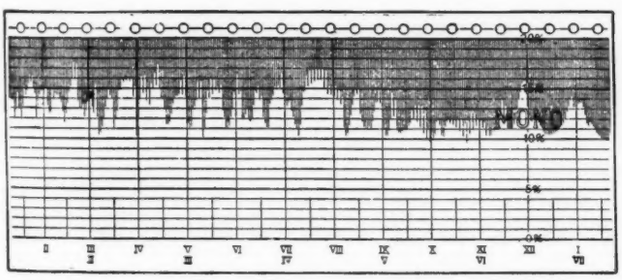


FIG. 5. HIGH CO_2 AND SLIGHT COMBUSTIBLE GASES

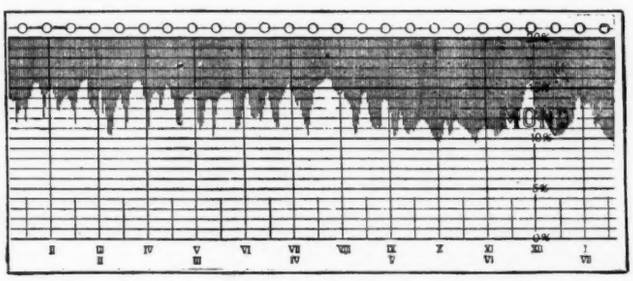


FIG. 6. CO_2 CHART CORRESPONDING WITH FIG. 5

[1] By Charles F. Wade, page 750, May 10, 1921.

well be proud. It would easily pass inspection and probably give rise to favorable comment on the part of his superiors. But the actual results of the fireman's efforts were bad, as shown by the chart, Fig. 3, made at the same time and showing the amount of combustible gases as well as CO_2. Uneconomical combustion was still taking place, since much combustible gas was escaping up the flue. This was due to incorrect amount or distribution of air and a dirty, uneven fuel bed—

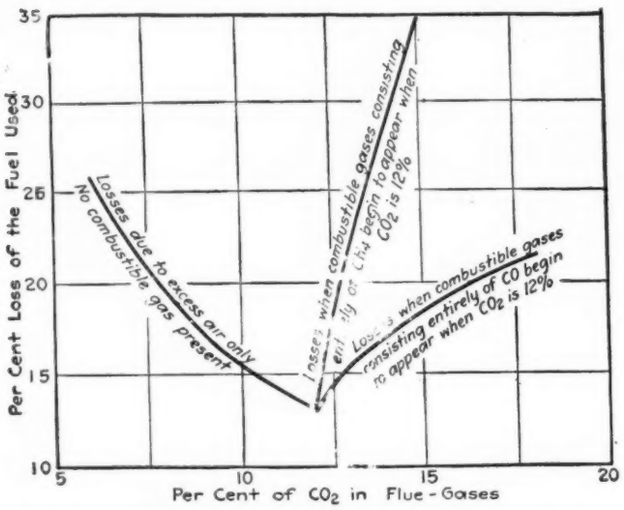


FIG. 7. CURVES SHOWING LOSSES FROM EXCESS AIR, CO AND CH

in other words, bad draft regulation and poor firing. These wasteful conditions could easily have been avoided by proper attention to the fire and dampers had the fireman been aware at the time of what was actually going on, but these conditions could not possibly have been discovered by him from the record of CO_2 only, as given in chart, Fig. 4, according to which he apparently was doing exceptionally well.

In the third test the fireman was given a fair opportunity to show what he could really accomplish toward the realization of maximum fuel economy when constantly informed of all the results of his efforts—results concerning which he is ordinarily in ignorance. To this end the chart which shows the presence of combustible gases as well as the percentage of CO_2 in the flue at all times was explained to him and the new instrument placed at his disposal as a guide in place of the one recording CO_2 only.

Since the Duplex instrument detects and records combustible gases whenever they appear and simultaneously makes a continuous accurate record of the percentage of CO_2 present, he had the advantage of a continuous complete record of the results he was getting. A prompt danger signal developed in the form of a lightly shaded area on the chart whenever combustible gases began to appear. When the fireman saw such an area appearing, he lost no time in hunting for and stopping the cause, all the while maintaining as high a record of CO_2 as possible. The result was a chart with comparatively little lightly shaded area.

Chart Fig. 5 shows how combustible gases may appear with varying percentages of CO_2. At about a quarter of three the percentage of CO_2 in the flue was carried as high as 16 before combustible gases made their appearance, but at ten o'clock combustible gases were present with a CO_2 record as low as 10 per cent, but whether combustible gases appeared at high or at low percentages of CO_2, they were always promptly detected and eliminated. It is, therefore, clear from a study of Chart Fig. 5 that CO_2 records with occasional snap tests for CO offer no insurance against serious losses due to either excess air or incomplete combustion.

It is interesting, in passing, to take a look at Chart Fig. 6, showing CO_2 alone. The fireman paid no attention to the instrument that produced it during this last test. Since combustible gases were present during only a small part of the time and in a very slight degree during this last test as a result of the guidance offered by the Mono instrument, this record looks very much like Fig. 5, which shows both CO_2 and combustible gases. It would have been dangerous to maintain such a high record of CO_2 had the fireman no means of detecting unconsumed combustible gases. The figures in Table I have been calculated from other measurements made during the test.

TABLE I. SHOWING UNNECESSARY FUEL LOSSES AND THE CAUSES

Fig. No.	Basis of Control	Pounds of Steam per 10,000 B.t.u. in Fuel	Cost of 1,000 Lb. of Steam, Fuel Costing $9.07 Per Ton	Unnecessary Flue Losses in Per Cent of Fuel Used	Causes of Losses Not Evident from CO_2 Record Only
2 1	Recorder of CO_2 only	5.44	$0.662	22.5	Leaky boiler setting, dirty fire, poor firing, bad draft regulation.
4 3	Recorder of CO_2 only	5.95	0.606	12.1	Poor firing, bad draft regulation, dirty fire.
5 6	Instrument recording combustible gases as well as CO_2	6.66	0.54	0	No causes—best possible conditions existing.

Unneecssary losses amounted to 22.5 per cent of the coal consumed in the first test when the boiler settings were leaking. After repairing the boiler settings, the unnecessary losses still totaled 12.1 per cent, the method of firing and draft regulation being faulty. The last test, where all these unnecessary losses were eliminated, shows what can be accomplished if the fireman is provided with the proper guide that will show at a glance what is going on.

Unnecessary losses are here considered to be such losses as could have been avoided by keeping CO_2 at the maximum demonstrated as possible in the last test without having combustible gases escape up the flue. Since no other changes were made in the course of these tests except those mentioned, the losses which were eliminated in the last test as compared with the first must all have been due to excess air and the escape of combustible gases. Why the escape of combustible gases makes such a big difference in the economy is evident from a glance at the values that are plotted in Fig. 7.

Although the rate at which the percentage of combustible gases increases is usually much greater than the rate at which the percentage of CO_2 increases beyond that point where combustible gases begin to appear, these calculations are based on the conservative assumption that the rate at which the percentage of combustible gases increases is equal to the rate at which the percentage of CO_2 increases. That is, combustible gases are assumed to increase by only 1 per cent for each 1 per cent increase in CO_2 beyond 12 per cent, where combustible gases in this case were assumed to make their first appearance.

The Duplex Mono used in these tests is illustrated in Fig. 8, which shows the instrument open. No moving mechanical parts are used to force the gas through this apparatus. Mercury is used instead and also performs the functions of valves.

On the chart every other line represents the results of a CO_2 analysis (CO_2 only being absorbed from the sample). The intermediate lines represent the results of analyses for combustible gases as well as CO_2 (both CO_2 and combustible gases being removed from the sample). The difference in length between any two succeeding lines is proportionate to the amount of combustible gases present in the two samples recorded.

Samples analyzed for CO_2 and combustible gases combined are passed through an electric furnace. Here the combustible gases CO, CH_4 and H_2 are converted into

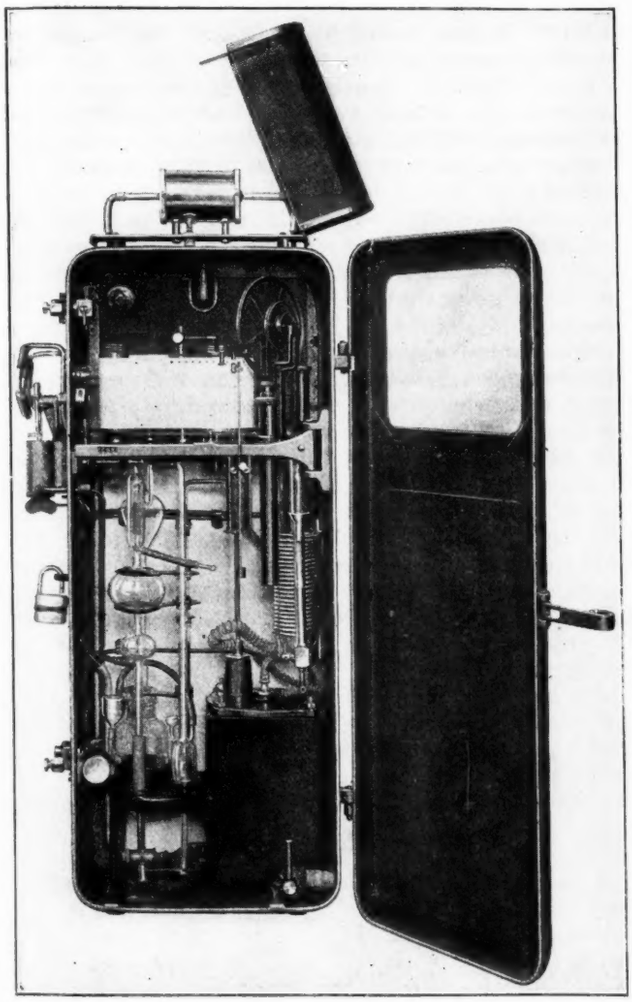


FIG. 8. DUPLEX MONO INSTRUMENT, COVER OPEN

CO_2 and H_2O. When there is not sufficient oxygen in the flue gases to oxidize the combustible gases, the necessary oxygen is supplied by copper oxide placed in the electric furnace for that purpose. Ordinarily, however, the necessary oxygen is taken from the flue gases, which almost invariably contain sufficient free oxygen for that purpose, the copper oxide acting merely as a catalytic agent.

The CO_2 originally in all samples, as well as that formed by the oxidization of CO and CH_4 in the alternate samples which pass through the electric furnace, is removed by passing the gas through a caustic-potash solution. H_2O formed in the electric furnace through the oxidization of H and CH_4 in alternate samples is condensed. The analyses for CO_2 alone are accurate within 1/10 of 1 per cent. The indications for combustible gases, not being intended for accurate measuring purposes, are exaggerated on the chart.

Ignition Failures in Diesel Engines

BY LOUIS R. FORD

If, when attempting to start a Diesel engine, ignition of the fuel fails to occur, it may be attributed to one or more of the following causes: Insufficient fuel; low compression; fuel injection too late; failure of spray-air supply; cylinders too cold. If the engine does not start promptly, the engineer should not waste starting air by repeated trials without making an investigation to locate the cause, always eliminating the most obvious possibilities first and leaving until last the inspections that require considerable work in the way of disassembly of parts.

INSUFFICIENT FUEL

Insufficient fuel or total failure of fuel supply to cylinder may be caused by an empty fuel service tank or by a closed stop valve in the fuel line between measuring pump and tank, and these should be checked up first. On some types of fuel-measuring pumps the air-starting gear and pump mechanism are not interlocked in such a way that the pumps are automatically put into operation when the engine begins to turn with air. In such a case it may happen that the pump levers are not set in the operating position before starting.

Because of the small quantity of oil handled per stroke by the fuel-measuring pump and the high pressure pumped against, this pump is very sensitive to air that may be present in the oil. A fundamental requirement in good pump design is that no pockets may be permitted in the oil passages in pump or valve chamber, where air might collect, but many pumps have been and are still being built that do contain such pockets. Most pumps are provided with vent valves so that the collected air may be blown out. Sometimes the fuel may be prevented from reaching the pump by an air pocket in the pipe between the pump and the tank.

The most common cause of failure of fuel supply is leakage of air past the check valves in the fuel lines to the spray valves. In all closed-nozzle-type spray valves the mixing chamber in the valve body, where the spray air and oil mix before entering the cylinder, is always in direct communication with the spray-air system and consequently is filled with air at injection pressure. In order for the fuel pump to force the oil into this chamber against the air pressure, it is essential that the oil pipe be full of oil right up to the inlet to the valve chamber, so that when the pump forces a small amount of oil into the pump end of the pipe, an equal amount will be forced out of the other end into the valve chamber.

It is obvious that if this pipe is partly filled with air, the oil column, when acted upon by the charge of oil being forced into the pipe by the pump, will simply compress the air and no oil will be discharged into the valve. If the discharge valve of the fuel pump is perfectly tight, no air from the spray-valve chamber can force its way into the oil pipe after the pipe is com-

pletely filled with oil, but the fine grit present in nearly all fuel oil makes it very difficult to keep this valve perfectly tight very long. For this reason practically all Diesel-engine builders install a check valve in the oil line to each spray valve, as close as possible to the point of entry of oil into the spray-valve body. This valve closes against the air pressure in the spray-valve body so that the oil column in the pipe is subjected to pressure only during the time the pump is discharging into the line at one end and forcing the oil through the check valve at the other. With this arrangement a pump will work quite satisfactorily even though the discharge valve is not perfectly tight, as long as the check valve remains tight.

Testing the Spray Valve

This valve can be tested while the engine is stopped, by turning spray air from the bottles into the air line to the spray valve and then opening the bypass in the fuel-oil line near the check valve. If the valve leaks, the air will blow out of the bypass. If there is no bypass in the line, the oil pipe may be disconnected at the pump and the air will blow out there. Before making this test, the engine must be jacked around until the spray valve, to which is attached the line being tested, is in the closed position, so that the spray air will not blow into the cylinder. In order to provide additional insurance against spray air leakage into the fuel oil lines, some builders provide two check valves in each oil line and two discharge valves in each pump.

Leaky suction valves in the fuel pumps, or valves stuck open, may be responsible for the failure of the oil to reach the cylinders. Examination of the valve and seats will usually indicate a leaky condition.

When the fuel contains considerable water, the water may settle to the bottom of the supply tank, while the engine is stopped, in sufficient quantity to fill the pump, so that water instead of oil will be injected into the cylinders. The obvious remedy for this is to drain all the water out of the system before attempting to start the engine.

Compression Too Low

If the compression in the cylinders is not high enough, the temperature of the air in the cylinders will be too low to ignite the oil. If the compression is due to leaky cylinder head or valve-cage gaskets, or leaky relief valves, the leakage will be indicated by the noise of the escaping air. Other causes are leaky inlet, exhaust or air-starting valves, and stuck piston rings. The methods for remedying these defects are obvious and will not be further enlarged upon.

Fuel Injection Too Late

If the fuel is not injected into the cylinders until after the compressed air has started re-expanding as the pistons move away from the heads and increase the cylinder volume, the temperature of the air may have fallen so low that it will not ignite the oil, and the effect produced is the same as in the case of low compression. This late injection may be caused by the adjustable nose on the spray-valve operating cams slipping. The clearance between cams and rollers may be too great or the valves may be clogged so that the fuel does not flow rapidly enough. The cams should be examined to see if they have slipped on the shaft; if they have not, then the cam toes may need advancing by means of the adjusting screws. The rollers should be examined to see if any are badly worn or broken. Each valve should be checked with the dial plate or the valve-setting marks on the flywheel.

If the spray valves are clogged so that the fuel is retarded in its passage through the valves, an abnormal rise in spray-air pressure will be noted if the compresser suction is open wide when the engine is turning on starting air. The valves should be disassembled and all sediment and carbonized oil that may have accumulated cleaned out.

Failure of Spray Air

The capacity of the spray-air bottles is often so small that if the spray-air compressor does not begin charging immediately upon starting the engine, the result will either be complete ignition failure or ignition will occur for a few revolutions, then fail as the pressure in the bottles falls. When this occurs, no further attempts to start should be made until the compressor trouble is located and remedied.

The most common causes of loss of compressor capacity are broken or leaky valves. The location of the defective valve may be determined by observing the gage pressures in the different stages while the engine is turning over. An abnormal rise in pressure in the first or second stage indicates that air is leaking back through the discharge valve in that stage. Rise of pressure in the high stage may indicate a closed stop valve in the discharge line to the engine, clogged strainers or clogged spray valves.

If an excessive amount of lubricating oil is used in the compressor, a jelly-like emulsion will be formed, which will lodge in the strainers and interfere with air flow. If the compressor shows loss of capacity, with pressure below normal in all stages, it may be due to obstruction of the suction of the first stage. In the case of compressors that are regulated by throttling, this suction loss of capacity may be found to be due to the suction valve being closed. Another cause for rapid loss of spray-air pressure is sticking of spray valves. If a spray-valve stem jams in its guide so that the valve is not forced back to its seat by its spring, the spray air will blow into the cylinder during the whole cycle and so much air will be blown away that the pressure in the system will fail. A condition of this kind will make itself known by very severe explosions in the affected cylinder, due to preignition of fuel that has been blown into the cylinder too early in the cycle.

Cylinders Too Cold

If the jacket-water circulating pump is started before the engine, it may happen that the cylinder walls and cylinder heads may be chilled to the point where ignition is interfered with, this condition being most likely in cold climates, during the winter months when the cooling-water temperature is very low. This cooling affects the ignition in two ways; it reduces the temperature of the compressed air in the engine cylinders and it also increases the viscosity of the fuel oil after it is deposited in the spray-valve cavity, so that atomization of the oil is more difficult and its passage through the valves is retarded. In cases where this trouble is experienced, it is best not to start the cooling-water circulating pump until after the engine is started. When steam is available, it is advisable to make a connection to the water system so that the circulating water may be heated and the cylinders warmed up before starting the engine.

EDITORIALS

The Man and the Job

MANY a man reckons his success from the day he got his job. He had spent years before in character building, in fitting himself to assume responsibilities and render service, but it was when opportunity came, when he found his niche in life, that his career really began.

Many an employer reckons his success from the day that he got his man. Not a few businesses depend upon their organization, their personnel. They have begun to go big from the time certain men made them their life work.

It is a great service to connect the man with the job, the worker with the opportunity; and the service is likely to be just as valuable to the employer as to the man that he takes on.

Such a service is being rendered without charge or cost to either party by the Employment Service of the Federated American Engineering Societies, at the Engineering Societies' Building, 29 West Thirty-ninth Street, New York.

The Federated American Engineering Societies is a combination of scientific and professional engineering societies of the country, comprising a membership of some fifty thousand for co-operation in matters of common professional interest. This is one of its minor activities, but it is doing it on a large and liberal scale, for the good of the profession. The service is not only gratuitous, but is not confined to the members of the constituent societies. If you are looking for a man or a position involving engineering training, write or phone (Vanderbilt 4600) to the address given and help them to render somebody else a service in rendering one for you.

It may mean the finding of a genius for you and a start in life for the genius.

Air Economizers

ENGINEERS in former years have frequently considered the possibilities of economizers placed in the flue gases to heat the air entering the furnace instead of the water entering the boiler. While a few attempts have been made to do this, especially in Europe, air economizers have never become recognized as standard practice except at sea. It is now reported that air economizers or preheaters are contemplated for several large power stations, and thus interest has been renewed in this equipment.

Air preheating is used quite extensively in British marine service in the well-known Howden system of forced draft with Scotch marine boilers. The air is forced by fans through tubes placed in the smoke flue above the boiler. It then passes down through a casing inclosing the uptake and is said to be delivered under the grates at a temperature between two hundred and two hundred and fifty degrees Fahrenheit. The heating surfaces are only moderately large, and the system seems to give satisfaction in service. However, inquiries have failed to reveal any reliable test data of actual performance.

Air preheaters have also been used in the breeching of English-built Bettington boilers for use with powdered coal. The object of preheating the air in this case is to increase its moisture-absorbing capacity before this air enters the coal pulverizer, which is of the fan-bladed type. The coal is more readily dried and pulverized by this means. This form of air economizer is also of relatively small proportions.

Some locomobiles in Germany have been fitted with an unusual arrangement. A standard type of water economizer has been placed in the flue gases, and the heated water is circulated through air preheating coils on the air supply to the furnace. The air is heated about one hundred degrees Fahrenheit by this arrangement.

It is said that the coefficient of heat transfer in an air economizer varies from two to three B.t.u. per square foot per degree Fahrenheit difference in temperature per hour. It will be apparent that excessively large surfaces will be required in the preheater to heat the air one hundred degrees, which under average conditions corresponds to a fuel saving of about three per cent. The air economizer would operate under a few inches of water pressure only and should be cheaper to install than a water economizer. When it is proposed to install an air economizer in the smoke flue beyond a water economizer, it will be apparent that either large surfaces or high air velocities will be required to effect the necessary heat transfer. It has been estimated that such an arrangement will produce a fuel saving of one and one-half per cent. Its economic value will depend on load factor, which must be high to warrant the installation.

Considerable trouble is experienced with burnt-out grate sections with some coals on forced-draft stokers. It will be apparent that these troubles will increase if the air supply is heated to a high temperature in an air economizer.

It is questionable whether the expense of an air economizer is justified by the present prices of coal in this country. There is the further consideration of added complication in the power system.

Pulverized Coal Versus Stoker Firing

DURING the last twenty years development in power-plant equipment has been very rapid, and with this development the mechanical stoker has kept pace. Evidence of this is found in the fact that types of stokers that had a wide application to large boilers fifteen years ago have since been discarded and replaced by more modern types capable of high rates of driving.

It has been during this period of development that pulverized coal under boilers has been competing for recognition and much credit is due those that have made pioneer installations. In this issue P. F. Coffin,

in an article, "Pulverized Coal Versus Stoker Firing," calls to attention many interesting features regarding the two methods.

Results obtained in the Milwaukee Electric Railway and Light Company's Lakeside plant, burning a fairly good grade of coal in pulverized form will undoubtedly arouse new interest in this method. The remarkable over-all boiler and economizer efficiency of over ninety per cent obtained in this plant when operating the boiler at one-hundred and thirty-six per cent rating shows what may be done with pulverized coal. Undoubtedly, these results will spur stoker designers on to develop still more efficient equipment, and if methods of firing boilers with pulverized coal can be developed so that a considerably higher efficiency can be obtained under normal operation than with stokers, then the latter may be at a disadvantage.

The relative economic value of fuel in power stations is well illustrated in the case of a new turbine that excels an older one in steam economy by one per cent. If the new machine can be operated continuously on a base load, the cost of the fuel saved, when capitalized, will often pay for the new machine and make it possible to scrap the old one or to relegate it to peak-load service. It is, therefore, evident that if a saving of from three to ten per cent or more in fuel economy can be made by the substitution of pulverized coal for old installations of stokers, the cost of the change will soon be offset by the saving in fuel. In the case of peak-load stations the saving of one-half the fuel required for banking fires, referred to by Mr. Coffin, will be just as important as a saving of similar magnitude in the fuel used for carrying the base load.

Reducing the "Blow-Down" to a Science

NOT many years have passed since steam pressure and water level were practically the only measurements required in the routine of a first-class boiler plant. In recent years the science of measurement has stormed and captured many a stronghold of "Rule of Thumb." The great majority of these victories were honest ones. In other words, where the determination of facts by measurement has supplanted arbitrary rules or guesswork, it has usually been because the results obtained were enough better to pay well for any additional expense or trouble that might be involved. Refinements that do not meet this test are merely fads and soon pass out of use. The measurement of coal, ash, feed water, steam flow, superheat, vacuum, flue temperature, carbon dioxide and draft have all been found to pay under certain circumstances and some of them under practically all conditions.

In this issue Mr. Azbe, in an article entitled "Concentration of Water in Steam Boilers," seeks to place on a scientific basis the routine operation of "blowing down" boilers. It is evident that there is an opportunity to make a real saving if the amount of hot water wasted in this manner can be kept at the minimum consistent with freedom from priming and other troubles. Like other refinements this must pass the test of practical experience and show savings commensurate with the expense and trouble involved before it can be generally accepted by engineers. The prospects for this seem bright, and particularly so if the very simple "densimeter" method of measuring concentration can be used instead of a cumbersome chemical method.

What Do You Know About Water-Backs?

AFTER many years in active service the water-back ought by this time to have proved its usefulness and its limitations, provided many interesting experiences and offered ample opportunity for the average stationary engineer to understand its field and performance. Yet the actual information on water-backs in general is rather vague, and there seems to be considerable misunderstanding among engineers as to its present status.

At a recent meeting discussion seemed to indicate that some of the engineers present considered the water-back unnecessary and a source of trouble on account of burning out and wasting heat. The discussion showed such a lack of understanding that it would surely be of benefit to start a discussion on water-backs and endeavor to collect data on performance.

Is it not true that a water-back, with the chain-grate stoker, results in better performance of the stoker? Does not the presence of a water-back improve the condition of the fuel bed by compressing it and making possible the desired density at the rear of the grate? Does it not allow the coke to be retained on the upper stratum of the fuel bed until the carbon is consumed, while allowing the refuse to tumble into the ashpit? The contact between the water-back and the fuel bed and the higher density of the latter permit of higher carbon dioxide because excess air entering at the rear of the grate is eliminated. Therefore, does not the water-back result in higher combustion efficiency?

As to furnace maintenance, the water-back is subject to, but is well able to resist, the erosion and attrition that would otherwise fall to the refractory, so that there is reduced wear and tear of the brickwork, the adherence of ash and clinker to the bridge wall is reduced and attendant troubles disappear.

When water-backs first came into vogue, trouble was encountered on account of their becoming dry and burning out. Water alarms and similar contrivances were adopted to prevent this. The best remedy from all aspects was to pipe the feed water through the water-back, in this way assuring a supply of water and at the same time utilizing the heat absorbed from the fuel bed.

The facts here cited are fairly obvious and, in a general way, cannot be denied. What is wanted is concrete information upon the subject. Is there any experience showing the relative importance of the water-back in increasing combustion efficiency for different coals, in enabling higher rates of combustion per square foot of grate surface, in making more satisfactory the use of forced draft under chain grates, in heating the feed water and reducing the loss of unburned carbon in the ashpit? Can it be proved that the water-back has lowered the maintenance cost of refractories or increased the length of time a furnace is able to remain in continuous operation without repair? When should it be used and when not used?

In other words, with all the water-backs in use, cannot the engineers operating them come forward and give their experiences to others? The subject is an interesting one because, as the forced-draft chain-grate stoker increases in numbers, the water-back may be expected to increase also. A discussion of the subject should bring to light some valuable experiences and put aright some of the misunderstandings now existent.

CORRESPONDENCE

Discharge-Pipe Connections for Centrifugal Pump

The inference given in the article, "Discharge-Pipe Connections for Centrifugal Pump," page 943 of the June 7 issue, is incorrect. The motor will not be less, but will be more heavily loaded by reducing the friction head, just as an electric generator is more heavily loaded by reducing the resistance in the external circuit.

The power demand of a centrifugal pump at any given speed is determined by the weight of water delivered, and anything that tends to increase the weight of water delivered adds to the load on the motor; any reduction in friction head increases the quantity delivered.

Centrifugal pumps used for mine drainage have had their motors burn out when the discharge pipe burst, which reduced the discharge head and this increased the delivery.

Mr. Dixon, therefore, will increase the overload on his motor if he follows his hydraulic friend's advice.

Jersey City, N. J. WILLIAM A. FRANK.

The Drying of Pulverized Coal

On page 762 of the May 10 issue appears a paragraph from a paper by L. L. Hebberd, entitled "The Drying of Pulverized Coal." I take exception to the statement made therein regarding the necessity of driers.

The Allegheny Steel Co., which is the first example given, is located near coal mines where the coal can be obtained with a very low average of moisture content, a purely local condition and one which cannot in any way serve as an illustration for general practice. The second example refers to the Ford Motor Co.'s installation. This installation has been in operation but a short time, and there is no information as yet available to show that they have successfully overcome the need for driers.

Four direct benefits are obtained by the use of properly designed driers. Of these the first is the improvement in pulverizing conditions, which is bound to occur as the moisture content is reduced. The second is the greater efficiency obtainable, both theoretically and practically, when the moisture is eliminated before the coal reaches the boiler furnace. This is due to the fact that the gases from the driers pass away at considerably lower temperatures than the gases from the furnace. In the third place, although coal may be obtained with a very low moisture content in a given locality, this moisture content is bound to vary and will usually rise at times to a degree that will make predrying essential to the proper preparation of the coal. In the fourth place, no one other factor can make so much trouble in the handling and distribution of pulverized coal as moisture. Inasmuch as the drying process increases the ultimate efficiency of the combustion of fuel, it may be considered an essential part of the preparation of pulverized fuel except under very unusual and localized conditions.

At the new Lakeside plant of the Milwaukee Electric Railway and Light Co. it has already been proved that the use of driers is essential to the satisfactory operation of the plant.

H. G. BARNHURST, Advisory Engineer,
Allentown, Pa. Fuller Engineering Company.

Scale in Boiler-Feed Pipes

I have read Mr. Green's article on page 862 of the May 24 issue of *Power* relating to troubles with scale in boiler-feed pipes. I suggest as a remedy to arrange the feed-pipe lines as shown by Fig. 1, where it will be seen that four elbows could be eliminated by piping, as shown by the dotted lines *A* and *BB*, with a plug or gate valve *C* below the reducing cross. The plugs in *D* and *E* allow for inspection for scale formation in the

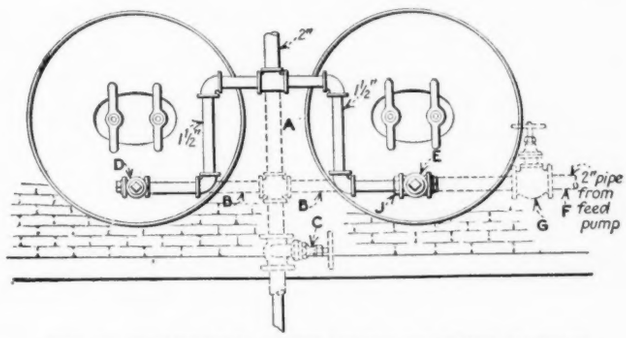


FIG. 1. PROPOSED ALTERATION OF FEED PIPING

pipe. The 2-in. pipe line could be connected as shown by the dotted line *F* to the reducing tee at *E* and continue with a 1½-in. pipe to *D* with the combination checks used as stated or not and a check and stop valve at *G*. Such an arrangement would allow for cleaning the pipe.

Most drums of water-tube boilers are provided with a flange bolted to the head, through which the feed pipe passes into the boiler. In return-tubular boilers the feed pipe passes through the head or shell and in some cases extends back about three-quarters of the

length of the shell, across to the center and forward to just back of the manhole and discharges between the tubes in the center part of the boiler so as to avoid discharging against the seams.

In Fig. 2 is shown the front tube sheet of a boiler with a bushing having a hexagon nut and a flange which forms a shoulder at the end of the thread and which, when screwed against the head, makes a rigid support for the feed pipe and prevents much of the vibration of the internal pipe coming on the thread alone. The external feed pipe is screwed into the bushing, also the internal pipe. Carelessness of steamfitters in using a surplus amount of pipe-joint cement on the inner thread of the boiler bushing is the cause of many feed pipes becoming choked up in the bushing *H*.

The internal feed-pipe arrangement shown in Fig. 2 was found in a 72-in. boiler that had the pipe *I* extending across the top of the tubes about three feet from the rear head with a cap on the end, the pipe being perforated with ⅜-in. holes to distribute the water more evenly. One day it was found impossible to get water into one of my boilers. It was shut down, and upon removing the section it was found plugged almost solid with scale. As the feed water entered the boiler at 210 deg. it is no wonder that the pipe scaled. It was cleaned and the cap was removed and an elbow put on in its place with a 12-in. length of pipe extending down-

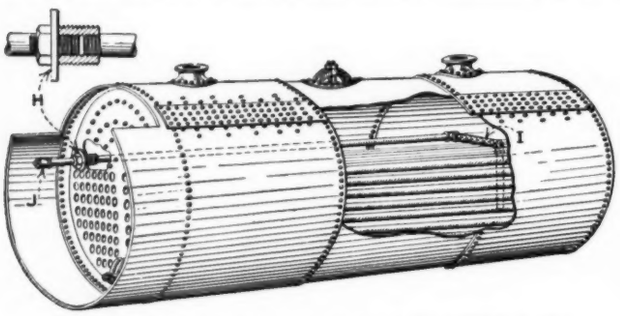


FIG. 2. FEED-PIPE BUSHING AND FEED-PIPE ARRANGEMENT

ward between the tubes and the shell, as shown by the dotted lines, and left open at the end. The perforations allowed even distribution of the water, and the open end prevented the pipe from becoming choked. A plugged tee was put on the end of the pipe at *J*, instead of an elbow. By removing the plug, obstructions could be punched out with a rod, as far as the inner elbow.

In another boiler plant trouble had been experienced with the internal feed pipe. The bushing in the tube sheet was made of brass, and it had been leaking to such an extent that the boiler head was reduced in thickness around the bushing. The bushing had not been screwed in up to the head because of a shoulder on the end of the thread. As the head was ½ in. thick, there were not more than seven threads to withstand the vibration of the internal pipe, which was so severe that the pipe broke off flush with the inside end of the bushing. The boiler accumulated considerable scale, and the joint at the rear head and the shell had been calked. The internal feed pipe was suspended from S-hooks and strap irons clamped horizontally across the through braces. The feed pipe ran to about 18 in. of the rear head, where it crossed to the other side of the boiler and turned down with a short outlet piece between the tubes and the shell of the boiler. The short pipe pointed toward the rear head, as shown by Fig. 3, and discharged the water against the flange of the rear head, depositing scale all over the rivets and tubes as shown, which caused a leak between the head and the sheet. The end of the feed pipe partly plugged up and the force required to force water through this restricted opening, together with the pulsations of the feed pump, caused the pipe to jump out of its end hook, which eventually resulted in a broken pipe connection at the bushing in the front head.

The horizontal feed pipe was fitted with a cross-pipe at the rear end and extended as shown by the dotted line, discharging between the tubes in the center just back of the manhole, so that the water would not be discharged in close proximity to any shell seam. Before

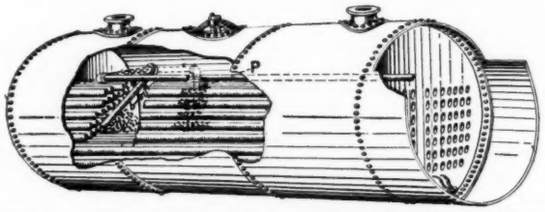


FIG. 3. FEED-PIPE ARRANGEMENT THAT CAUSED SCALE ACCUMULATION

this was done, a new steel bushing replaced the brass one and was screwed through the head with a white and red lead mixture between the flange on the bushing and the boiler head. A nipple was cut with a long thread to screw through the bushing so that a coupling could be used to connect the external and internal feed pipes, and the rear S-hook was made long enough to bend around the brace and feed pipe.

There was no more trouble with scale on the shell, although it did accumulate in the end of the pipe and around the pipe between the tubes *P;* but as the feed-pipe discharge was under the manhole, a few blows with a hammer on the feed pipe detached the scale in the pipe and working a bar between the tubes easily cleaned out the accumulation of scale between them. If the pipe was perforated or slotted for two or three

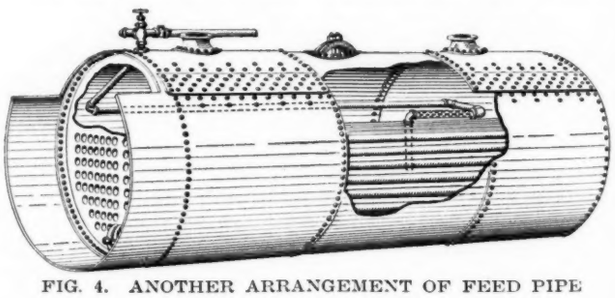


FIG. 4. ANOTHER ARRANGEMENT OF FEED PIPE

feet from the discharge pipe, less scale would form around the end of the pipe and on the tubes.

Fig. 4 shows the feed pipe entering the boiler through the top of the shell about a foot back from the front head, with a 45-deg. elbow and pipe connecting with the internal pipe, which was run about three-quarters the length of the boiler, then across to the center of the tubes and then forward to a point a little back of the manhole, where it turns downward between the tubes. The return horizontal pipe is perforated as shown. However, scale formed in the end of the pipe. Scale also clogged the diagonal pipe, which was eventually changed to come in through the front.

R. A. CULTRA.

Cambridge, Mass.

Motors for Driving Fans and Blowers

I note with interest a series of articles in your recent issue by Gordon Fox, on motor drives on various equipments, and my attention is called particularly to the issue of April 26 in which Mr. Fox discussed "Motor Drives for Fans and Blowers." One statement that he makes I desire to take exception to; namely, "Propeller fans are used for pressures less than 1 oz. per sq.in.," inasmuch as propeller fans are today being used extensively for pressures far beyond 1 oz. There are, I may say, thousands of propeller-fan turbine-driven blowers operating to provide forced draft under furnaces burning anthracite, where the pressures are for 2 and 3 in.; that is, up to almost 2 oz. Also, in numerous instances these blowers are being used to provide forced draft for underfeed stokers where pressures called for are 3½, 4, 4½ and even 5 in.; in other words, pressures up to almost 3 oz. per square inch.

V. H. CARPLES, Sec. & Treas.,
Newark, N. J. L. J. Wing Manufacturing Co.

Why Belts Run Up

In the May tenth issue of *Power* Harry S. Curtis asked why belts "run up."

It is a common contention that a belt should "run down" on a tapered pulley or, in other words, should

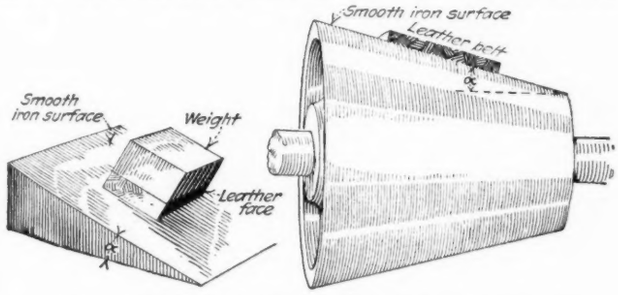


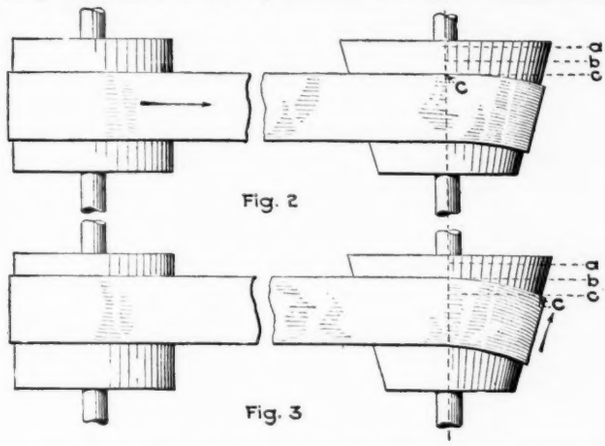
FIG. 1 TAPERED PULLEY COMPARED WITH AN INCLINED PLANE

slip toward the smaller end actuated by the tension of the belt.

It is quite true that on a tapered pulley, just as on an inclined plane, there is a component tending to cause slipping toward the "lower" side. However, the friction produced by the pressure is more than enough to prevent any slipping until a certain angle α, called the "angle of friction," is reached. In Fig. 1 the angle α is the "angle of friction" provided it is such that the weighted leather (or belt under tension) will just start to slip down the incline. The "angle of friction" is, of course, dependent upon the nature of the materials in contact and the conditions of their surfaces, but it does not depend on the surface of contact or the weight (tension in case of the belt). It is approximately the same for a pulley as for an inclined plane and is in the neighborhood of 25 deg. for leather in contact with smooth iron. Since pulley tapers are ordinarily very small, no slipping can take place by inclined-plane action alone.

If a belt is hung between the centers of a straight and a tapered pulley, with shafts horizontal and parallel, the tapered pulley gives the belt, when stretched, the curve indicated in Fig. 2. If the point *C* on the tapered pulley just touches the edge of the belt it will carry that point of the belt in a plane *c* perpendicular to the axis of the pulley. After the pulley has rotated 90 deg., the point *C*, with the adjoining edge of the belt, will have moved to a position shown in Fig. 3. This brings the oncoming edge of the belt to the line *b*. Another quarter turn will bring the belt to the line *a*. Therefore the belt "runs up" in the direction indicated by the arrow.

With a "crowned" pulley the two halves of the belt, being on conical surfaces, tend to "run up" to the center

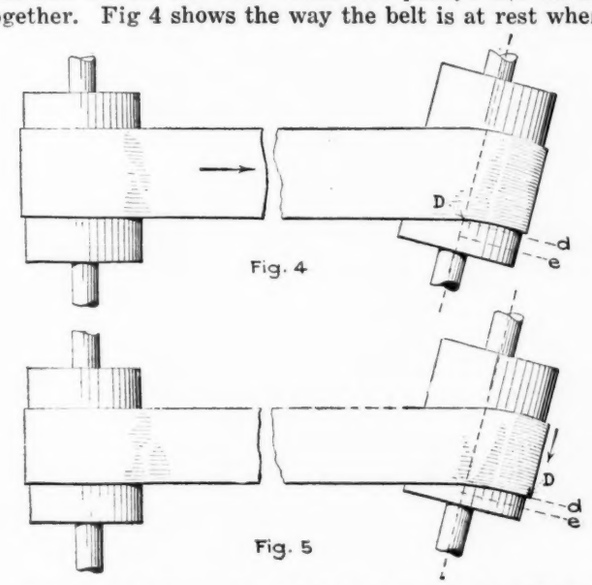


FIGS. 2 AND 3. PLAN VIEW OF BELT CONNECTING CONICAL AND STRAIGHT-FACED PULLEYS

Fig. 2—Starting position of belt. Fig. 3—Position of belt after quarter revolution.

with the result that it is given a firm path in the center of the pulley.

In the case of two straight pulleys the shafts of which are in the same plane but not parallel, the belt will run off on the side where the pulleys are closer together. Fig 4 shows the way the belt is at rest when



FIGS. 4 AND 5. PLAN VIEW OF BELT CONNECTING STRAIGHT-FACED PULLEYS HAVING SHAFTS AT AN ANGLE

Fig. 4—Starting position of belt. Fig. 5—Position of belt after quarter revolution.

stretched between the centers of the two pulleys whose shafts are in the same horizontal plane. If the right-hand pulley grips the edge of the belt at a point *D* of its circumference, a quarter revolution will carry that point of the belt in the plane *d* and the belt will then be located as indicated in Fig. 5. It is evident that a few turns of the pulley will cause the belt to run off in the direction of the arrow.

It is thus seen that a belt does not always run to the "high side." It would be nearer the truth to say that it runs to the greatest diameter, but even this does not always apply. RUDOLPH WILDERMANN, E.E.
Weehawken, N. J.

A belt will go to one side or the other of a pulley according to how it is led on. When a wire is wound on a mandrel in a lathe, the wire goes to the right or left according as the hand that feeds it moves in one direction or the other. A quarter-turn belt will run all right in the direction it is designed to run, but the engineer who backs up his engine will run off every quarter-turn belt in the mill, because the belt will not feed squarely onto the pulley in the reverse direction.

If the shafts are out of line, as in Fig. 6, or if one pulley is slightly conical, as in Fig. 7, the belt will be

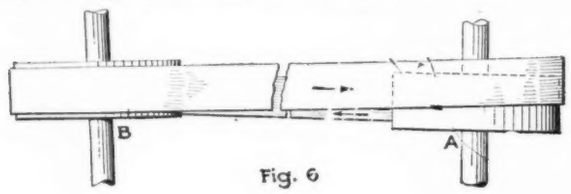


Fig. 6

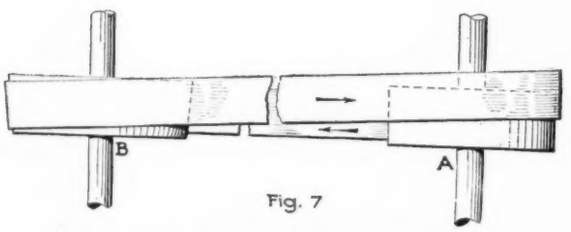


Fig. 7

FIG. 6. STRAIGHT PULLEYS OUT OF LINE
FIG. 7. ONE PULLEY TAPERED

thrown in the direction indicated as it leaves the pulley *B*. If it were inflexible, it would follow the lines shown, being fed off still farther with each succeeding turn. Although the belt may bend sideways, there is always the force required to bend it tending to pull it over to the "high" side of the pulley. RALPH P. EMERSON.
Chelsea, Mass.

Furnace Capacity

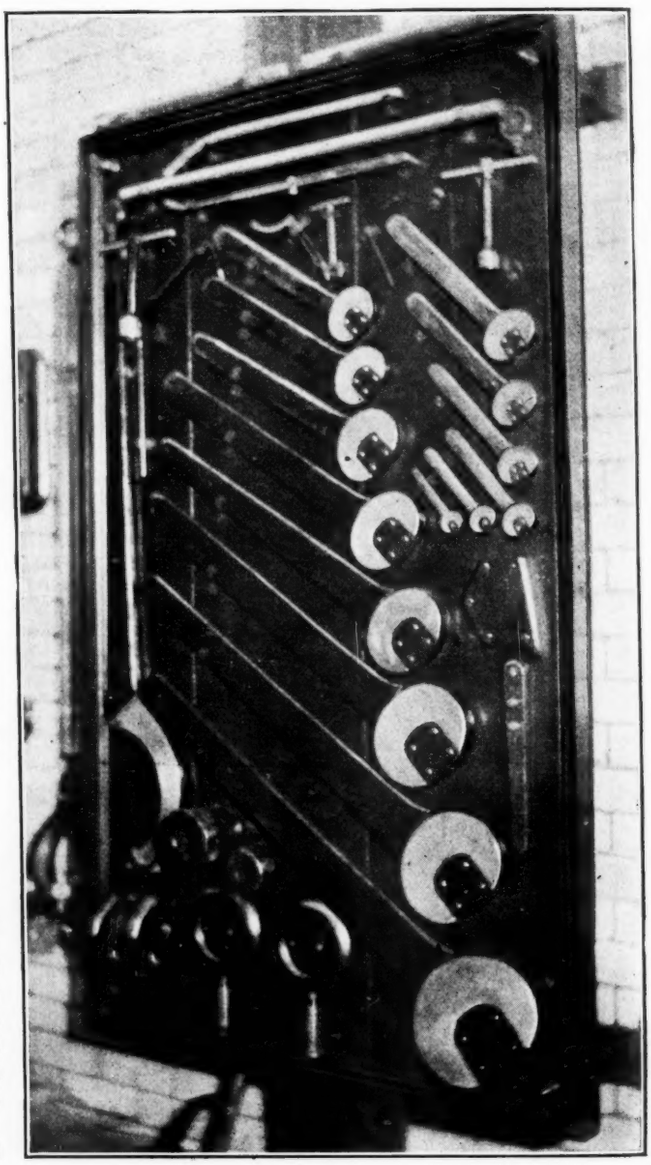
In reading the interesting description of modern power plants in *Power* lately, I notice that the relation between furnace volume and combustion rate is given in cubic feet per pound of coal per hour. Since we have become accustomed to speaking of combustion rate with relation to grate surface in pounds per square foot per hour, would it not be more logical and also more readily understood to speak of pounds per cubic foot per hour with reference to the furnace volume?

In going over the different descriptions, I have noted that in the large up-to-date central stations the furnace volume is designed on the basis of a normal combustion rate of from 1 to 2 lb. per cubic foot per hour and a maximum rate from 2.5 to 3. I have also noted that Mr. Kreisinger's reports in his tests of the powdered-coal-burning boilers at Milwaukee, that the best results were had at from 1 to 1½ lb. per cubic foot per hour and a maximum rate of 2 lb. Why the difference? Can we logically explain a large furnace for powdered-coal firing, or are we going to increase stoker-fired furnaces still more and bring the two figures closer together?
Kewanee, Ill. C. C. COBB, JR.

An Attractive Wrench Board

Years ago there was in a Boston theater an engine room that was the show place of the city. All units were painted white and one of the attractions, to those of a mechanical turn of mind, was a fine cloth-lined tool case, in which reposed wrenches and tools such as are ordinarily used about an engine room, all nickel plated, but evidently never used.

The accompanying view of a wrench board is one that was recently seen in a large power plant. The tools are not nickel plated, however, and are for real

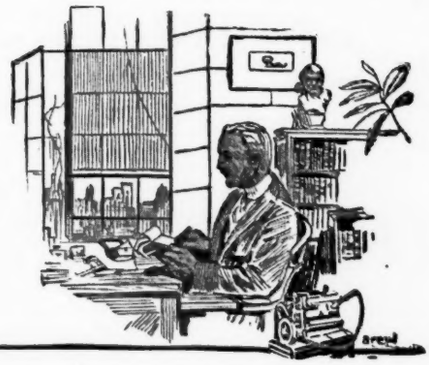


POWER-PLANT WRENCH BOARD

use. The board is about four feet high, and each wrench is held in place by a block screwed to the back face of the board and of such shape and size as to fit in the jaws of the wrench. The handle end of each wrench is held in place by a spring clip which is also secured to the board. Other tools are seen in place around the edge of the board.

Such a method of caring for wrenches keeps them in view, and everyone knows where they are when wanted.
Baltimore, Md. J. C. MILLER.

INQUIRIES OF GENERAL INTEREST



Clearance for Piston Diameter of Diesel Engine—How much clearance diameter should be given between the piston and bore of a Diesel engine? W. G.

Diesel engines operated with splash lubrication require about 0.001 in. diameter clearance for each inch diameter of cylinder; and for forced-feed lubrication, which usually is less effective for piston cooling, the clearance to be allowed is about 0.0015 in. for each inch of cylinder diameter.

Diameter of Tubes of Fire-Tube Boiler—What diameter of tubes should be used in a 66-in. x 16-ft. horizontal return-tubular boiler? W. R. B.

For boilers operated with natural draft the common rule is to allow one inch of nominal tube diameter for each 4 ft. of length when bituminous coal is used, and one inch of diameter for each 5 ft. of length when the fuel is anthracite. To conform with the rule, tubes 16 ft. long should be 4 in. in diameter for use with bituminous coal and about 3¼ in. in diameter for use with anthracite. With mechanical draft smaller tubes can be used, according to the force of draft that is employed.

Injection Water for Oil Engines—What advantage is gained in the operation of an oil engine from injecting water into the cylinder? J. S.

In some low-compression oil engines, such as those which employ hot-bulb ignition, water injection is used to prevent preignition. More power is thereby obtained, not from any thermal advantage, but because it is possible for the engine to carry a greater load without preignition. The advantage is sometimes attributed to the expansive force of the steam that is generated, but the heat required for evaporation of the water, although small, would be of greater advantage in development of power if employed to increase the expansive force of the products of combustion.

Thickness Required for Boiler Shell—What thickness of shell would be required for a horizontal return-tubular boiler 72 in. in diameter to carry a working pressure of 138 lb. per sq.in. with a factor of safety of 4.5 and tensile strength of material 55,000 lb. per sq.in.? S. L.

The required thickness of plate would depend on the strength of the weakest course, computed from the efficiency of the logitudinal joint as well as the tensile strength of material, diameter of shell, working pressure and factor of safety. The working stress per inch length of the longitudinal joint would be $72 \times 138 \div 2 = 4{,}968$ lb. If the efficiency of the joint is 80 per cent, then with 55,000 lb. tensile strength of material and a factor of safety of 4.5 the allowable stress per inch length of shell for material one inch thick would be 80 per cent of $55{,}000 \div 4.5 = 9{,}777$ lb., and for the working stress of 4,968 lb. the required thickness of material would be $\frac{4{,}968}{9{,}777}$ in. $= 0.508$, or practically one-half inch.

Relation of Flow to Velocity and Cross-Sectional Area—For estimating sizes, capacities and velocities in pump passages, what are the formulas for determining the number of gallons discharged per minute for given velocity and cross-sectional area; the required cross-sectional area for given number of gallons per minute and velocity per second; and the required velocity per second for given number of gallons per minute and given cross-sectional area of the passage? A. V.

The general expression for flow in gallons per minute is given by the formula

$$G = \frac{a \times v \times 12 \times 60}{231} = 3.12\,av$$

where G is the number of U. S. gallons per minute, a is the cross-sectional area of passage in square inches, and v is the actual velocity of flow in feet per second. From the general formula,

$$a = \frac{G}{3.12\,v} \text{ and } v = \frac{G}{312\,a}$$

Why Protect the Main Bus?—In most modern alternators the leads leave the machine with a clearance of only a few inches between them. In many the two ends of one phase are brought out with a clearance of less than one inch, although in two-phase and three-phase-delta machines there is full line-voltage between these leads. Yet it is customary in modern power-plant design to provide minimum clearances of 15 to 18 in. between the different phases of the main bus and to isolate carefully each phase in a concrete or brick compartment. Barriers of brick or concrete are also placed between generator and feeder leads connected to the bus. Is this policy consistent, and if so, what reasons is it based upon? A. L.

It is true that clearances in the main-bus circuits are much greater than those existing in and around the generator, but this is not inconsistent. The difference is partly due to the fact that the separate phases are carefully wrapped with insulating materials, both in the windings and around the terminals of the machines; this, however, is a minor consideration. Even if it were practicable to insulate the main busbars, it would be good practice to keep the phases isolated in separate compartments. The basis of modern power practice is continuity of service. Since all the power comes from the main bus, it is the backbone and the most important part of the plant and should be protected in every possible manner against electrical or mechanical damage. The severity of surges and other disturbances resulting from short-circuits is very much greater in the bus than in the generator circuits, owing to the larger amount of power supplied to the bus, and it is correspondingly difficult to localize such troubles and avoid a complete shutdown. This to a certain extent explains the need of large clearances and isolated compartments. But the object of this construction is not only to provide adequate insulation against electrical disturbances, but also to resist the heavy mechanical strains set up in the bus structure by the magnetic fields due to short-circuit currents and to protect the bus against accidental contact or damage from the outside. Safety to human life is also an important reason for inclosing the bus.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communication and for the inquiries to receive attention.—Editor.]

Advances in the Art of Waterwheel Designs and Settings*

By W. M. WHITE†

THE UTILIZATION of our natural resources for the development of power, its transmission and the employment of that power to relieve man of burdensome toil has been an outstanding feature in the progress of Western civilization during the last half-century.

Of the total power developed in the United States, that furnished by water forms no inconsiderable part, amounting now to approximately nine million horsepower. It has been estimated that fifty million horsepower can be developed from the rivers within the borders of the United States. Of the nine million horsepower, by far the major portion has been developed in the last thirty years.

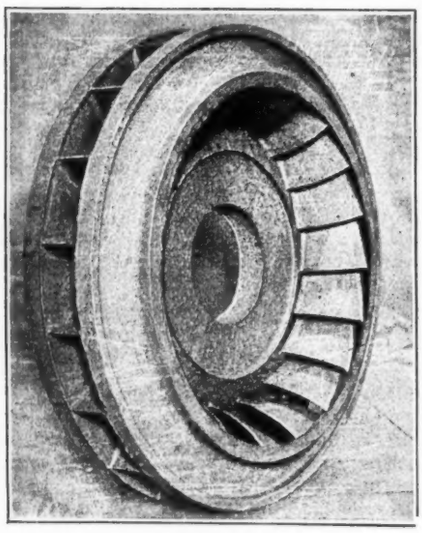


FIG. 1. FIFTY-FIVE INCH RUNNER
8,000 hp., 415-ft. head, 450 r.p.m.

The early American types of waterwheels were peculiarly adapted to the locality in which they were made. From the New England States, with their meandering streams and low falls, came the inward-flow, reaction turbine wheels, and out of the mountainous West, with its precipitous streams and great falls, came the Pelton, or impulse wheel.

The work of J. B. Francis, of Lowell, Mass., was a notable contribution to the art, resulting in the development of the inward-flow, axial discharge wheel which is essentially the present waterwheel runner of the reaction type. Splendid results were obtained by the early designers by the cut and try method.

The modern trend is to develop completely any given power site. The number of units in the given plant is dependent upon the service to be rendered by that plant. The network of transmission lines is now becoming so extensive that isolated power plants are the exception rather than the rule, as formerly. In an isolated power plant it was necessary to divide the development into several units, usually at least four, so that continuity of service could be maintained by allowance for repairs and renewals. Most of the isolated early developments have now grown to huge dimensions with many interconnected plants and are in many cases, interconnected with adjacent companies. At present many companies have lines of interconnection reaching into several states. The hydro-electric station in the large systems today is the unit just as the individual waterwheel and generator were the unit years ago. The engineer is at liberty, therefore, to handle this unit in any manner that will make for economy in construction, efficiency in operation and reliability of service. All three of these considerations really demand the same thing—the largest single unit that can be installed, in the particular development under consideration, thus doing away with several small units with an additional spare unit.

Having determined the size of unit for a particular setting, its speed is practically fixed for that head. A formula that has been used for some time as fixing the upper limits of speed is as follows:

$$r.p.m. = \frac{\left(\frac{5050}{H+32}+19\right)H^{5/4}}{\sqrt{hp.}}$$

where H equals head acting on the turbine and $hp.$ equals the maximum horsepower of the turbine.

The formula applies to a single runner, and in the case of multi-runner units the maximum horsepower of the unit is to be divided by the number of runners and the horsepower per runner substituted in the formula.

There is probably no other feature in the design of a hydro-electric plant that has received more discussion than the question of the unit's speed. There are several contending forces: The electrical engineer desires usually the higher speeds in order to cheapen the cost and frequently increase the efficiency of the generator. On the other hand, the waterwheel designer usually prefers his lower speed for better emergency throughout and, certainly, for higher efficiency at lower or part gate loads and for freedom from troubles in the field, such as pitting, erosion and vibration.

The size of waterwheel units has steadily increased to such a point that now the cost of the generators does not vary as widely with the change in speed, so that it may result that, in the design of larger units now in general contemplation, this troublesome question may settle itself.

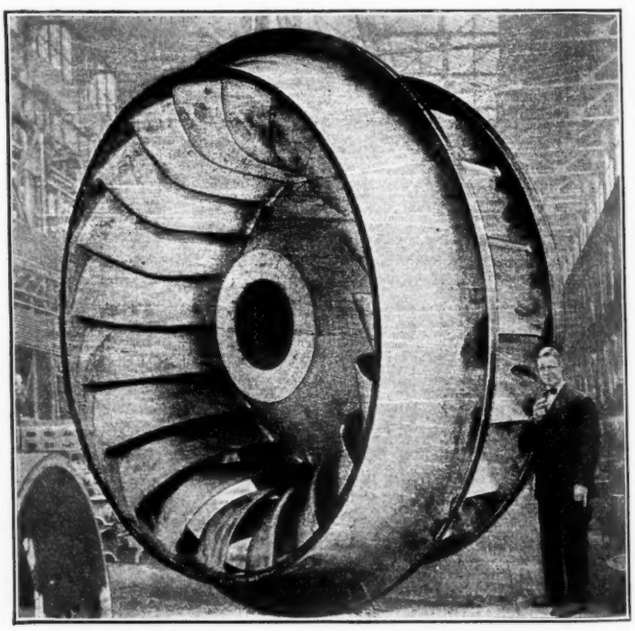


FIG. 2. CAST-IRON, 125-IN., RUNNER FOR NIAGARA FALLS POWER CO.
37,500 hp., 215-ft. head, 150 r.p.m.

Speed Regulation

The great inertia of the mass of water moving to and from the waterwheel produces difficulties in the regulation of the speed of the waterwheel unit which can best be controlled by making use of the inertia of the revolving parts of the waterwheel and generator. The greater the inertia of the enclosed supply water the greater must be

*Abstract of paper presented at the Annual and Pacific Coast Convention of the A. I. E. E., Salt Lake City, June 21-24, 1921.

†Manager and chief engineer, Hydraulic Department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

the inertia of the revolving parts to give good regulation. The factors entering into the control of the speed are: (a) The time in which the water is shut off from or turned on the unit; (b) the increase or decrease of the effective head on the turbine occasioned by such change; (c) the inertia of the revolving mass which resists change of speed by acting as a resorvoir for the energy unabsorbed otherwise.

The governing apparatus is frequently unfairly charged with poor regulation, when all that apparatus can do is

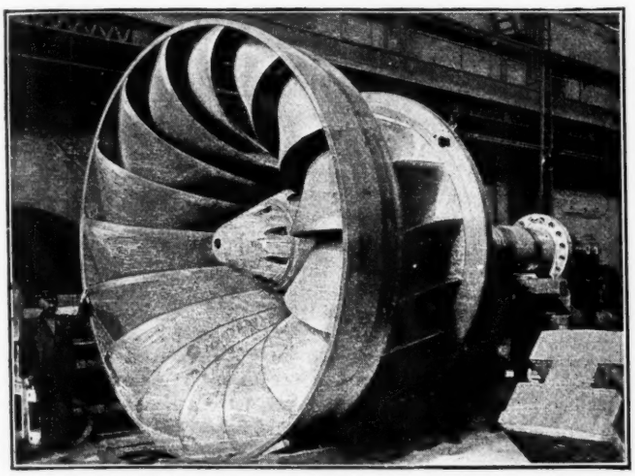


FIG. 3. CAST-IRON RUNNER FOR CONCRETE SPIRAL CASED TURBINES
68-ft. head, 90 r.p.m.

to open or close the turbine gates within a predetermined time when actuated by a change in speed.

The resulting change of effective head operating on the turbine caused by the movement of the gates within a given time is dependent upon the velocity and length of the column of water. Manifestly, open-flume turbines are easiest of all to regulate. Turbines having long pipe lines with high velocities cause greatest difficulties in regulation. Modern governors are equipped so that they may be readily adjusted for moving the gates open or closed in a predetermined time. There is usually a different time for closing and opening the gates in order to avoid synchronous waves in the pipe line.

The most important single piece in the make-up of the waterwheel is the runner. The function of all the headworks, supply lines, casings, speed rings and guide vanes is to deliver to the runner the maximum amount of energy with proper relation of velocities and pressure, and the function of the proper draft tube or regaining devices beyond the wheel is to return to the runner, in the form of added head, the maximum amount of energy. The function of the runner, therefore, is to transform the maximum amount of energy delivered to it into mechanical power on the waterwheel shaft.

The number of vanes or buckets in the runner varies from thirteen to twenty-four, depending on the specific speed of the runner and the head under which it operates. The condition to be satisfied in the selection of the number of vanes is that enough be used to form passages through the runner sufficiently smooth in shape to avoid eddies and cross-currents, and yet that not so many be used as to cause too great a friction loss. Another factor in determining the number of vanes is the question of the pitting or erosion which is caused by the use of too few vanes. The diameter of the runner at discharge is contracted until a balance is arrived at between the loss due to the velocity discharged from the runner and the friction loss saved by reduction of vane surface.

The problem of determining mathematically the results of flow in a straight pipe is so dificult that any mathematical formula attempting to predict the results of a given runner under a given condition has no place in this paper. Probably no single part of any apparatus has been fixed more by cut and try and experimental methods than the runner of a waterwheel.

Figs. 1 to 5 show typical designs for various operating conditions and clearly indicate the change of bucket shape with increasing specific speed. Fig. 1 is a runner having a specific speed of 21.5, designed to operate under a head of 415 ft. Fig. 2 is a runner of 34 specific speed, designed to operate under a head of 215 ft. Fig. 3 is a runner of 67.7 specific speed, designed to operate under a head of 68 ft. The runner shown in Fig. 4 has a specific speed of 94 and is designed to operate under heads below 30 ft. Fig. 5 shows a four-bladed Nagler wheel having a specific speed of 137.

The runner, being subject to greater stresses and greater wear than any other part of the waterwheel, should have wearing rings and wearing surfaces wherever possible to facilitate ease of repair.

The ideal runner material is bronze, preferably made without any zinc. A composition that has been found eminently satisfactory for this purpose is composed of 90 parts copper and 10 parts tin with a trace of phosphorus. It is economical to use bronze runners on high-head units provided the runners are not too heavy. Cast-steel runners have been used with excellent results on high-head and intermediate-head units. Cast-steel is desirable on high-head large runners that are heavy. Cast-iron runners have been used with success on the highest-head turbines, although they are not as satisfactory as the steel, because at these high heads the velocity of any foreign material flowing through the guide vanes is so great as to break out portions of the cast iron. Cast-iron runners are entirely satisfactory for all heads, say, from 200 ft. downward.

A type of runner that has been used with considerable success for intermediate and low heads, is one in which the vanes are made of plate steel pressed from forms and then cast integral with cast-iron crowns and cast-iron outer bands. These runners have the advantage of having very smooth surfaces resulting in less skin friction.

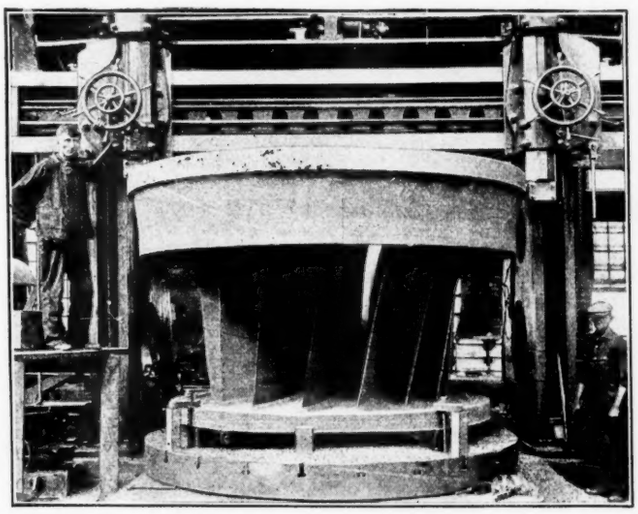


FIG. 4. EIGHTY-INCH RUNNER WITH STEEL PLATE VANES
600 hp., 9-ft. head, 60 r.p.m.

They also have the added advantage that the runner vanes may be bent back into position after having once been bent by foreign material entring the runner, which does happen from time to time.

The twofold function of the draft tube is not usually understood. Its function is, first, to inclose and seal a passageway from the runner to a point below the surface of the tailwater so as to produce a suction action at the discharge from the runner, at least equivalent to the difference of elevation between the runner and the level of the surface of the tailwater; second, to transform the energy in the form of velocity head discharged from the

runner into energy in the form of pressure head, thus creating an added suction at the discharge of the runner equal in amount to the velocity head times the efficiency of conversion. This amount added to the difference of elevation between the bottom of the runner and the level of the tailwater gives the total added suction at the runner. Therefore, by converting the discharge velocity into pressure by means of some proper form of regainer and thus maintaining a greater suction at the runner, the discharged energy is used by the waterwheel runner for the production of effective power.

A complete vacuum will cause the water to rise within it to about 34 ft. above the level of the outside water, the exact amount depending upon the air pressure at that particular locality and time. The height, therefore, at which a runner may be located above tailwater level is limited. It has been found that a runner of moderate specific speed should be placed so that the maximum suction at the base of the runner does not exceed 27 ft. theoretically. In determining the theoretical suction there is added to the elevation of the runner above tailwater the total velocity head in the water discharged from the runner; that is the efficiency of conversion is assumed to be 100 per cent. This is the limit of good practice, and where possible, other things being equal, the height should be made less. When large runner shafts are placed in a horizontal position, the center line of the shaft is necessarily kept low with relation to the tailwater elevation in order to keep the top of the runner at discharge within the limits as set forth. This elevation of the shaft frequently depresses the generator into the foundations below the level of high tailwater and sometimes of even normal or low tailwater.

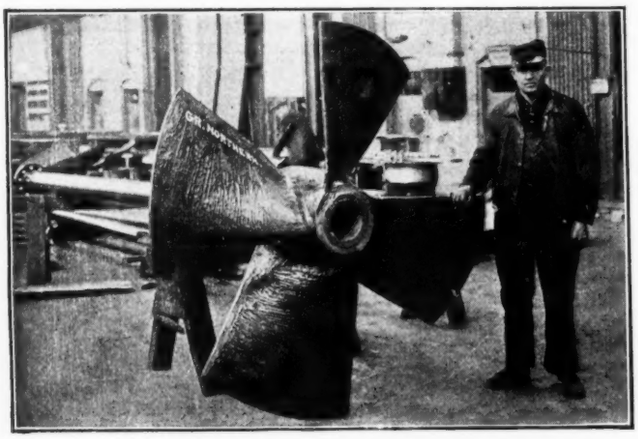


FIG. 5. SEVENTY-TWO-INCH HIGH-SPEED CAST-STEEL NAGLER RUNNER
600 hp., 17½-ft. head, 200 r.p.m.

The regain of energy from the velocity discharged from the runner may be accomplished more or less effectively by (a) straight conical tubes, (b) curved draft tubes and (c) hydraucone regainers.[1]

Straight conical tubes will regain the energy with high efficiency provided the space available within the power-house foundations is ample for the installation of a long conical tube having a length of preferably more than four times the diameter of the draft tube where it joints the runner.

Where space limitations render it impossible to use the straight conical tube it is necessary to resort to a curved draft tube or some type of hydraucone regainer.

Most of the curved draft tubes are a delusion and a snare. Recent investigations along these lines have shown that curved tubes now in use are so poor in regaining efficiency as to seriously detract from the power-plant efficiency.

In general a properly designed hydraucone gives much better results than a curved draft tube.

[1]Mr. White's article, "The Hydraucone Regainer," in the July 5 issue of *Power*.

The mainshaft is usually tapered and fitted into the hub of the runner. The shaft is sometimes made with a forged sleeve at the runner end to which the runner is secured by means of bolts. The former is the preferred method of fastening the runner when lignum vitæ bearings are used on the waterwheel, because by its use a renewable sleeve may be most cheaply and effectively applied to the shaft on which the bearing surfaces are caused to bear.

The trend of modern designs is strongly toward the cast-steel guide vane having stems cast integral and controlled by levers and operating mechanism placed outside of the water.

The number of guide vanes is fixed with the same considerations as that fixing the runner vanes. Enough vanes are used to form smooth passages for the water without introducing unnecessary skin friction. Average practise seems to favor the use of about twenty guide vanes of this type.

Governors and Governing

In the case of poor speed regulation the governor is usually charged with the failure to perform, whereas actually the governor itself is only one of three problems entering into the governing of a waterwheel unit, as already set forth. The function of the waterwheel governor in itself is the moving of the guide vanes a proper amount in the proper time and the readjusting of the guide vanes to the proper conditions of power and speed after the pressure rises produced by the movement of the vanes have been dissipated and conditions have returned to normal for that required power. The waterwheel governor has to perform more functions than any other type of governing apparatus, since it must move the gates to control the rise of pressure in the pipe line and the rise of speed caused by this rise in pressure.

Modern hydraulic governors are so sensitive that a change of speed of less than ¼ of 1 per cent will serve to move the gates to cause an adjustment of the guide vanes, and consequently the flow of water to compensate for the speed change.

Turbine Casing

In low-head open-flume plants the casing is omitted, but the walls of the flume are frequently shaped to form more or less of an open spiral so that the water may be directed smoothly to the runner. It is of prime importance that the water flowing to the guide vanes be kept free from eddies and whirls and as nearly an ideal stream flow as possible.

Vertical Versus Horizontal Units

The trend of modern design is toward larger and larger units and toward designs that will give the maximum amount of power from the energy of the water available. This naturally leads to the single-runner, vertical unit because the larger the waterwheel and generator the more nearly in accord are the economical speeds of the two. The larger the waterwheel runner the more difficult it is to place the runner with the shaft in horizontal position. The higher the specific speed of the runner the greater the energy in the discharged water; consequently, the more important it is to adopt a regaining device that will return the maximum amount of that energy to the runner for effective development of power.

A recent invention comprising snap rings disposed around the periphery of the disc of butterfly valves provides a means of making valves of this type substantially watertight. This should bring them into more general use because of their great simplicity and reliability in operation.

It is really a misnomer to speak of "modern" power house settings, because each power development requires a setting peculiar to its location, and that setting is modern only when there is brought to bear in its design experience gained on other power plants.

The best power-house setting can be obtained only by a careful analysis of all the factors, the aim being to produce a plant that will, after years of operation, prove the least expensive, considering not only the original investment but the operating and depreciation charges.

Canadian Engineers Meet at Ottawa

The thirty-second annual convention of the Canadian Association of Stationary Engineers was held at Ottawa, Ont., June 28-30, with headquarters at the Russell Hotel. In connection with the convention there was a mechanical exhibition of power-plant equipment and supplies, under the auspices of the Canadian Supplymen's Association.

The meetings of the delegates were held on the second floor of St. Patrick's Hall, while the main floor of the building was occupied by the supplymen in the display of their goods. There were 38 booths, and many new things in the engineering field were shown. The exhibition was generously patronized during the three days of the convention. There were upward of fifty delegates in attendance and many important measures were debated and voted upon.

A committee was appointed to work for the interchangeability of fourth-class certificates issued by the license board, which are now applicable only in the city in which they are granted.

It was announced that during the year there is to be an earnest endeavor on the part of the various local councils to increase the membership. The delegates agreed that there had always existed a grave lack of publicity, and to obviate this it was resolved to publish a monthly journal of the organization.

The present financial condition of the association was reported to be better than for the preceding five years.

On Tuesday morning the opening exercises of the convention took place. The hall was comfortably filled when Charles Berry, chairman of the local committee, took the chair and briefly outlined the aims and objects of the organization. Mayor Plant enlarged upon the manufacturing industries of Ottawa, told of the beauties of the city and warmly welcomed the visitors. After addresses by city officials and prominent engineers of the society, the gavel was handed to President Ross C. Leach, who appointed the required committees.

On Tuesday evening special cars took the delegates to Queen's Park, Aylmer, where boating, swimming, dining and dancing were enjoyed.

On Wednesday afternoon there was an auto trip through the city, ending at Exhibition Park, where outdoor games of many kinds were introduced, with prizes for the winners. The sports concluded in a baseball game between the engineers and supplymen, which was won by the latter with a close score. In the evening an entertainment was held in the exhibition hall, and a drawing for prizes ended a happy social evening.

At the closing session on Thursday afternoon the engineers elected and installed the following grand officers: Ross C. Leach, past president, Toronto; Fred Harper, president, Kingston; Henry Wright, vice president, Montreal; Louis J. Ellis, secretary-treasurer, Hamilton; George F. Galloway, conductor, London; Robert E. Rodney, doorkeeper, Ottawa.

The supplymen elected officers as follows: C. B. Turner, past president, Toronto; Grant E. Cole, president, W. Toronto; Edward B. Curzon, first vice president, Montreal; John Thompson, second vice president, Toronto; Lloyd M. Archibald, treasurer, Toronto; Gordon C. Keith, secretary, Toronto; Robert Jones, assistant secretary, New York; Earl F. Hetherington, chairman of entertainment committee, Galt; Evan A. Peterson, chairman of exhibits, Montreal; Robert A. Lyons, chairman of reception committee, Hamilton.

Announcement was made that the next convention will be held in Kitchener in June, 1922.

In a recent coal report of the Geological Survey it is shown that the time lost so far this year by bituminous coal mines in the United States on account of lack of demand amounts to about 49 per cent of full time, as compared to about 0.6 per cent in 1920. In that year about 43 per cent was lost through lack of transportation facilities, which have caused a loss of only about 0.7 per cent this year.

Iowa State N. A. S. E. Holds Annual Convention in Davenport

The Iowa State Association of the National Association of Stationary Engineers held its 21st annual convention June 22-24 in Davenport in the rooms of the American Legion. On the first floor was the auditorium, in which forty-four of the leading firms in and about Davenport engaged in engineering lines of industry arranged their exhibits, while on the second floor there was a hall in which 330 delegates and visitors participated in the sessions of the convention. The gathering was marked by harmony and good fellowship and was considered a big success.

The usual business affairs were handled in the morning of the first day, and in the afternoon the convention was formally opened by State President Harry G. Hammond. Mr. Hammond introduced Harry G. Metcalf, police magistrate, who, as the representative of the mayor, welcomed the delegates and guests to Davenport. The national secretary of the Association, Fred W. Raven, of Chicago, made the response to the address of welcome. General Secretary J. W. MacCarthy of the Chamber of Commerce followed with an entertaining historical talk on the City of Davenport. Royal H. Holbrook, state deputy of the association, took care of the educational feature of the program by presenting a paper in which he traced the history of smoke abatement from its earliest inception up to the present time. After this, congratulatory remarks were made by the president of the Manufacturers' Association.

The Exhibit Hall was formally opened in the evening, when a moving picture was presented by the Chicago & Wilmington Coal Co. of Illinois, entitled "The Story of Coal as Revealed Through the Mines."

On the second day, Thursday, there was a short business session, at which Abner Davis, state secretary, reported a continual increase in membership, and James A. Coulsen, state treasurer, reported over $800 in Liberty Bonds on hand. State Deputy Royal H. Holbrook presented an unusual report of his activities, as he had traveled over 12,000 miles in Iowa alone during the last year. The local chamber of commerce furnished automobiles for an excursion to the United States Arsenal at Rock Island, after which dinner was enjoyed in Forest Park. In the afternoon Thomas S. Marsh, chief engineer of the Green Engineering Co., gave an illustrated talk on "Progressive Combustion." In the evening there was a dance.

At the business session on the third day, Friday, the delegates from Des Moines announced their intention of securing the 1922 National Convention for their city, and the election of officers was held, resulting as follows: President, F. H. Elliott, of Mason City; vice president, F. E. Newkirk, of Sioux City; secretary, Abner Davis, of Cedar Rapids; treasurer, James A. Coulsen, of Sioux City; conductor, J. W. Timms, of Mason City; doorkeeper, William Viggers, of Des Moines; recommended as state deputy, Royal H. Holbrook.

Announcement was made that the 1922 Iowa State Convention will be held in Mason City in May.

Bear River To Give More Power

The preliminary permit asked by the Utah Power and Light Co., of Salt Lake City (authorized May 20), is for a power development in Bear River, in southeastern Idaho. A total development of 21,500 hp. is contemplated at four points, as follows: Soda Point, 6,000 hp.; Lava, 6,000 hp.; Narrows, 4,000 hp.; Mink Creek, 5,500 hp. It is proposed to make the power houses an integral part of the dam or construct them adjacent to the dam. The plan is to connect the plants to the company's high-tension transmission system. This company owns four other power plants on Bear River, of a total capacity of 104,000 hp., and has, altogether, a total installed capacity of 164,400 hp. in hydroelectric plants and 25,600 hp. in steam plants. The company owns the right to store flood waters at all seasons in Bear Lake and to release waters subject to the prior rights of other appropriators. These rights have been established by a final decree of the District Court of the United States for Idaho. The permit will be for a period of 33 months.

Efficient Operation of Oil-Burning Steam Plants*

By C. H. Delany†

During the last ten years there has been a remarkable increase in the efficiency of steam-electric plants, both oil-burning and coal-burning. Ten years ago there were many plants operating reciprocating engines, in which the maximum economy obtained was not over 150 kw.-hr. per barrel of oil. With the high-pressure steam-turbine plants of the present day a record of 330 kw.-hr. per barrel has been made. This improvement has been brought about mainly by introducing more efficient machinery and increasing the range of steam pressure in the prime mover. The introduction of the steam turbine to replace the reciprocating engine effected a remarkable saving in the quantity of fuel required.

Many tests have been published showing very high efficiency of boilers where fired with fuel oil, as high as 80 and 82 per cent being not uncommon in test reports. It is very rare, however, that any such high efficiencies are obtained in the regular operation of power plants. In order to maintain high efficiency in the regular operation of a plant, the first requisite is some means of comparing one day's operation with another. In oil-burning electric-power plants, it is customary to report the economical operation of the plant in terms of kilowatt-hours generated per barrel of oil. This is an excellent method of comparing one day's operation with another, provided there is a steady load on the plant and conditions remain the same from day to day. With a variable load, however, such as occurs in an ordinary central station, it is always found that the economy is much better at periods of heavy load and poorer at periods of light load. Thus it is possible, with a fairly heavy load on the plant, to secure from 220 to 230 kw.-hr. per barrel of oil without difficulty, whereas, with the same plant operating at a light load, it may be difficult to secure more than 150.

In order to improve these conditions and to interest the men in the problem of efficiency, it is essential to devise some means of comparing the performance of a plant from day to day. For this purpose a diagram, which I have called the Plant Characteristic Diagram, has been plotted, which consists merely in the plotting of the oil consumption against the kilowatt-hours generated.

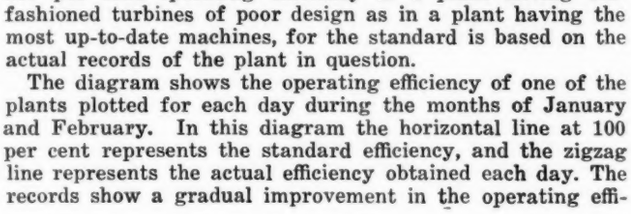
A diagonal line, having once been drawn through the points as described, may be used as a standard for the guidance of the man in the future operation of the plant.

There is one objection to the diagram—it does not indicate the order in which the records are plotted and therefore does not show whether the results are improving as time goes on. In order to overcome this objection and also to enable the operation of different plants to be compared with one another, the term "operating efficiency" has been introduced. Operating efficiency as used in this connection means the percentage of standard attained for the day's run. "Operating efficiency" is entirely distinct from "boiler efficiency" or "turbine efficiency" or "thermal efficiency" or "Rankine-cycle efficiency." All these entered into the operation of the plant in determining the standard. Operating efficiency is merely a comparison of the results actually obtained with the standard.

The method of determining operating efficiency can best be shown by an example: During one eight-hour shift there were generated 313,000 kw.-hr. and 1,440 bbl. of oil were burned, representing an economy of 217 kw.-hr. per barrel. From the diagram it is found that for a load of 313,000 kw.-hr. with standard efficiency, there would be burned only 1,400 bbl. of oil, which would be equivalent to 224 kw.-hr. per barrel as against the actual result obtained of 217 kw.-hr. per barrel. The operating efficiency is therefore 217 divided by 224, or 97 per cent. During another eight-hour shift, where there were only 25,000 kw.-hr. generated, the oil burned was 200 bbl., equivalent to 125 kw.-hr. per barrel. From the diagram it is found that for 25,000 kw.-hr. with standard efficiency the oil burned would be 220 bbl., equivalent to 114 kw.-hr. per barrel. The operating efficiency is therefore 125 divided by 114, or 110 per cent. It is thus seen that although in the second case there were only 125 kw.-hr. obtained per barrel, as against 217 in the first case, the operating efficiency was actually higher in the second case.

It is evident, therefore, that if an operating efficiency of 100 per cent is obtained, it means that the economy of the plant is the same as the average of last year, since last year's records were used to establish the standard. If more than 100 per cent operating efficiency is obtained, the results are better than last year, and if less than 100 per cent is obtained, they are worse. It is obvious that this method of determining operating efficiency makes allowance for inefficient machinery, and it is just as easy to obtain 100 per cent operating efficiency in a plant having old-fashioned turbines of poor design as in a plant having the most up-to-date machines, for the standard is based on the actual records of the plant in question.

The diagram shows the operating efficiency of one of the plants plotted for each day during the months of January and February. In this diagram the horizontal line at 100 per cent represents the standard efficiency, and the zigzag line represents the actual efficiency obtained each day. The records show a gradual improvement in the operating efficiency during the period, which is a direct result of the attention to small details brought about by this method of checking up efficiency.



COMPARATIVE EFFICIENCY DIAGRAM

In addition to the use of the diagram for setting standards and creating interest among the men, a system of weekly and monthly reports and bulletins has been adopted. The weekly report, which is made out by the efficiency man at each station, gives the operating efficiency for each day and the average for the week, and in addition a brief statement of some of the more important instrument readings such as flue-gas analysis, vacuum feed-water temperature and steam consumption of turbines at different loads. The monthly report, which is made out at the office and sent to each station, includes a diagram of operating efficiency similar to that shown, for all stations plotted on one sheet, together with a brief statement of comparative results obtained and suggestions for improved methods. A liberal use is made in the stations of flow meters and other instruments that serve as a guide to the firemen in the proper regulation of their fires.

To sum up, the essentials for securing the best efficiency in power-plant operation are:

1. A fair standard by which the daily performance can be measured and compared with previous results, at the same time giving the operating men a definite goal to work for.

2. Means of comparing results obtained by different groups of men such as different shifts of one plant or the crews of different plants, and the posting of this comparison so that the men can see the results of their efforts.

3. A system of reports that keeps up the interest of the men, combined with suggestions and advice that show where losses occur and how they may be avoided.

If the operating men are kept interested, see the results of their work and have a definite standard to reach, they will do their best. As interest flags, some sort of bonus or prize for the crew showing the best operating efficiency will stimulate them to greater effort, and by guiding this effort by means of thoughtful analysis of the technical features of the plant, maximum efficiency may be obtained.

*Abstract of paper read before the San Francisco Section of the A. S. M. E., March, 1921.

†Assistant engineer of operation, Pacific Gas & Electric Company.

Coal Legislation Receives Setback in Congress

The Frelinghuysen coal bills are dead. This seems to be the opinion of practically everyone except Senator Frelinghuysen. The New Jersey Senator told the correspondent of *Power*, after the Senate had voted to recommit his seasonal rate bill, that he had just begun to fight. "The coal bills have been delayed, not defeated," said he. "By misrepresenting things generally and particularly by claiming that the bills are regulatory, when they are not, the coal lobby scored a temporary advantage. As a matter of fact, the coal men have maneuvered themselves into an indefensible position. When the consumers of coal awake to the full realization of what has happened, it will be a serious thing for the interests responsible for the delay to this legislation. I hope it will not take another coal famine to overcome the indifference with which Congress is treating this legislation. The coal stabilization bill still is on the calendar. I shall call it up at the first favorable opportunity."

The discussion of the seasonal rate bill was brought to an abrupt termination by a motion by Senator Borah of Idaho that the bill be recommitted. This method frequently is used to kill legislation, particularly when no instructions are given as to amendments. The vote on the motion to recommit was 38 to 26. Most of the members of the Interstate Commerce Committee voted against the motion to recommit in deference to the committee's action in reporting out the bill. The vote developed a number of surprises. The first surprise was that Senator Borah—usually rampant in his atttitude against the so-called vested interests—should make such a motion. Senator Lodge and Senator Ladd voted together in favor of the motion to recommit. Senator Capper of Kansas, who was thought to be one of the strong supporters of the coal legislation, voted for the motion. The Senators who voted with Senator Frelinghuysen and who therefore may be judged as being particularly in favor of some Federal supervision over coal, were: Cummins, Iowa; Dillingham, Vermont; Hale, Maine; Hitchcock, Nebraska; Kellogg, Minnesota; Kenyon, Iowa; King, Utah; LaFollette, Wisconsin; McCumber, North Dakota; McKinley, Illinois; McNary, Oregon; Myers, Montana; Nelson, Minnesota; Nicholson, Colorado; Norris, Nebraska; Oddie, Nevada; Phipps, Colorado; Robinson, Arkansas; Shields, Tennessee; Shortridge, California; Stanley, Kentucky; Townsend, Michigan; Trammell, Florida; Walsh, Massachusetts; Walsh, Montana.

It is very evident that if Senator Frelinghuysen were to call up the stabilization bill at this time, it would be recommitted in similar fashion without delay.

The National Coal Association takes exception to Senator Frelinghuysen's statement that it assisted in the defeat of the seasonal rate bill. J. D. A. Morrow, in charge of the association's Washington office, declared that the association is absolutely neutral with regard to seasonal rates. Some of its members are strongly in favor of such legislation. In that connection Mr. Morrow expressed the opinion that the defeat of the seasonal rate bill should remove the uncertainty that evidently has been influencing many consumers to delay their purchases of coal. Now that it is known definitely that no such reductions are to be made in freight rates, buying of coal should be begun so that the mines can operate on a scale necessary to meet the winter's requirements. Mr. Morrow called attention to the recent warning issued by the Interstate Commerce Commission, which he interprets as being their notice to consumers that there will be no priority orders covering fuel transportation this winter. If New England and the Northwest do not buy coal now, when empty coal cars are available by the mile and mine workers are suffering from lack of employment, they should not expect special favors later on to make it possible for them to secure their fuel requirements.

Obituary

Dr. George Frederick Blessing, since 1908 dean of the engineering department of Swarthmore College, died June 25 in his summer home at Bay View, Mich., at the age of 46. Dr. Blessing was born in Carrollton, Ky., graduated from the State University of Kentucky and in 1908 married Martha Ripperdan White, of Lexington. He was the author of a number of textbooks on drawing and mechanical engineering.

Personals

F. S. Broadhurst, treasurer of Starkweather & Broadhurst, Boston, Mass., sailed July 2 for a six weeks' tour of Continental Europe.

Colin K. Carr has left the Firestone Tire and Rubber Co. to join the operating department of the Commonwealth Edison Co., Chicago.

Alex Dow, president and general manager of the Detroit Edison Co., has been made a member of the board of directors of the Detroit United Railway.

William S. Gould, formerly with John A. Stevens at Lowell, Mass., and Cleveland, Ohio, has taken a position in the engineering department of the Cleveland Discount Co., Cleveland.

M. A. Maxwell, formerly general manager of the Logan County Light and Power Co., Logan, W. Va., is now vice president and general manager of the Beckley Pocahontas Coal Co., Huntington, W. Va.

H. H. Horning, previously with the Cutler Hammer Manufacturing Co., of Milwaukee, has joined the power-engineering department of the Philadelphia & Reading Coal and Iron Co., Pottsville, Pa.

Nixon W. Elmer, formerly engineer for the Harry M. Hope Engineering Co., Boston, Mass., has opened an office in Quincy, Mass., as consulting engineer in conveying and mechanical handling of materials.

Allen V. Garrett has opened an office as a consultant in hydraulic engineering at 176 Federal St., Boston. He was formerly consulting hydraulic engineer with Lockwood, Greene & Co. and before that was chief engineer of the Lombard Governor Co.

T. Julian McGill has resigned as manager of the Chicago office of the Westinghouse Electric and Manufacturing Co., after 23 years with that company, to become vice president of the Twin City Rapid Transit Co., of Minneapolis and St. Paul, in charge of operation and public policy.

W. W. Headings is no longer chief engineer of the Carballoy Products Co., of Bellevue, Ohio, having secured a fellowship at the Carnegie Institute of Technology, Pittsburgh, Pa. He is an instructor in the physics department and is doing research work in developing carbons for electrical purposes.

G. C. Thornton has established an office as an electrical engineer at 308 First National Bank Bldg., Huntington, W. Va. He will specialize in designing and supervising construction of steam and electric power plants for mines, and in the mining and handling of coal by machinery. Mr. Thornton has installed several large plants in the Alabama coal fields and during the war served as a major in the Corps of Engineers.

Professor Arthur M. Greene, past president of the Society for the Promotion of Engineering Education, author of a number of technical books and prominent in the A. S. M. E. and other engineering societies, has been named dean of the enlarged School of Engineering of Princeton University. He will take up his new duties in the fall of 1922 and will also be professor of mechanical engineering at the school.

Business Items

The Brown Instrument Co., of Philadelphia, Pa., manufacturer of instruments for indicating and recording temperatures, pressures, speeds, operations, and drafts, has opened a branch office in Cleveland, Ohio, at 201 Reliance Bank Building, 1634 Euclid Avenue

The Metal and Thermit Corp. is putting into operation in South San Francisco, Cal., a new plant for the production of detinned billets. The former offices of the company at 329-333 Folsam St., San Francisco, have been moved to the new detinning plant, which will be in charge of E. Kardos, superintendent.

The C. & G. Cooper Co. of Mount Vernon, Ohio, has opened an office, Suite 626 Great Southern Life Building, Dallas, Tex., where those interested can procure information on all Cooper equipment, including Corliss steam engines, large horizontal heavy-duty gas engines for either direct-connected generator or compressor service, and the smaller single-acting direct-driven compressor units. H. P. Simpkinson, who has been transferred from the home office, is in charge of the new branch.

Trade Catalogs

The Jeffrey Manufacturing Co., Columbus, Ohio, has issued a 6 x 9-in., 215-page catalog of material-handling and other machinery. The book contains general descriptions, illustrations, dimensions and price lists of many different products, including the following: Chains and sprockets; conveyor and elevator details, transmission and gears; elevating and conveying machinery for various industries; coal-handling equipment for boiler houses or tipples; mining machinery, such as coal cutters, drills, locomotives, pit-car loaders and ventilating fans; coal crushers and pulverizers; portable loaders, etc.

The Warren Steam Pump Co., Warren, Mass., has prepared a series of five bulletins describing its products, as follows: "No. 101, Steam Heat Vacuum Pumps"; "No. 102, Horizontal Duplex Piston Pumps"; "No. 103, Vertical Single Piston Pumps"; "No. 104, Horizontal Single Piston Pumps"; "No. 105, Useful Information for Designing and Operating Engineers." The last-named booklet contains quite an amount of useful data on pumping practice, including, for instance, tables of standard flange sizes, friction loss in pipes, properties of saturated steam and directions for setting the valve gear of the Warren duplex pump.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

Coal	Market Quoting	June 28 1921	July 5 1921
Pool 1,	New York	$3.20	$3.00@3.25
Pocahontas,	Columbus	3.55	3.00@3.50
Clearfield,	Boston	2.20	1.80@2.40
Somerset,	Boston	1.95	1.70@2.10
Pittsburgh,	Pittsburgh	1.85	1.75@1.90
Kanawha,	Columbus	2.20	2.00@2.25
Hocking,	Columbus	2.10	2.00@2.25
Pittsburgh No.8	Cleveland	2.10	2.10@2.25
Franklin, Ill.,	Chicago	2.90	2.25@3.50
Central, Ill.,	Chicago	2.40	2.00@2.75
Ind. 4th vein,	Chicago	2.50	2.25@2.75
Standard,	St. Louis	1.75	1.75
West Ky.,	Louisville	2.00	1.75@2.40
Big Seam,	Birmingham	2.50	2.00@2.50
S. E. Ky.,	Louisville	2.25	2.00@2.50

New York—On July 6, Port Arthur light oil, 23@25 deg. Baumé, 4¼c. per gal. 30@35 deg., 5¼c. per gal. f.o.b. Bayonne, N. J.

Chicago—July 2, for 24@28 deg. Baumé, 40@50c. per bbl.; 32@34 deg. 1½@1¾c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—On June 20, f.o.b. refinery; Pennsylvania, 36@40 deg., 3¾c. per gal.; Oklahoma, 24@30 deg. 35c. per bbl., gas oil, 32@34 deg., 1¾c. per gal., 36@38 deg., 2¼c. 38@40 deg. 2¾c.

St. Louis—June 25, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 40c. per bbl.; 26@28 deg., 45c.; 28@30 deg. 50c.; 32@34 deg. 1¾c. per gal.

Philadelphia—On June 20, 26@28 deg., Baumé, Oklahoma, 3¼c. per gal.; 30@34 deg., Oklahoma (group 3) 2¾c. per gal.

Cincinnati — June 27, for 22@28 deg. Baumé, 6¼c. per gal.

Cleveland — June 27, for 22@28 deg. Baumé, 5c. per gal.

New Construction

PROPOSED WORK

R. I., Newport—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received bids for the installation of refrigerating equipment at the naval hospital here, from the York Mfg. Co., York, Pa., $5,910. John Manville, Inc., 296 Madison Ave., New York City, $6,827.

N. Y., Morris Park (Jamaica P. O.)—The Bd. Educ., 500 Park Ave., New York City, will soon award the contract for the installation of the heating, ventilating and temperature regulation systems in P.S. 657. About $30,000. C. B. J. Snyder, Municipal Bldg., New York City, Engr.

N. Y., New York — The International Paper Co., 30 Broad St., is in the market for a power unit consisting of a steam engine suitable for 125 lb. pressure, direct connected to a 200 kw. a.c. 3 phase, 60 cycle, 600 volts generator with exciter.

N. Y., New York (Manhattan Boro.)—Manhattan College, 131st St. and Bway., will soon receive bids for a college building on Spuyten Duyvil Parkway, opposite Van Cortlandt Park. About $1,000,000. J. W. O'Connor, 162 East 37th St., Archt. and Engr.

N. Y., New York (Manhattan Boro.)—The New York Edison Co., East 15th St., will soon receive bids for a 2 story, 40 x 100 ft. sub station at 224 East 52d St. About $175,000. Private plans.

N. J., Gloucester—Remington & Vosburgh, Engrs., 6th and Market Sts., Camden, will receive bids until July 15 for the installation of electric power pumps, pumping mains, etc., for the city. About $200,000.

Pa., Kittanning — The Templeton Limestone Co., c/o Harry & Wolfe, Purch. Agts., is in the market for a complete stone crushing plant, including conveyor engine, crushers, belting, etc.

Fla., Gainesville—J. H. Hodges, Supt., P. O. Drawer 508, will receive bids until July 17 for the construction of sewers and a sewerage disposal plant including one motor driven, direct connected 2 in., submerged centrifugal pump at the State Farm Colony for Epileptics and Feeble Minded, here.

Miss., Starkville — The Mississippi Agricultural College, will soon award the contract for a 1 and 2 story power house. About $50,000. Link & Trueblood, Chemical Bldg., St. Louis, Mo., Engrs.

Ky., Dawson Springs — J. A. Wetmore, supervising Archt., Treasury Dept., Wash., D. C., will soon award the contract for an electric sub-station at the U. S. Public Health Service Sanatorium here.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave. received bids for the installation of a steam heating system in the proposed 3 story, 40 x 140 ft. high school addition on Parkwood Drive and Everton Ave. from Feldman Bros., Barrett Ave., $39,850.

O., Kent — The Western Reserve Cotton Mills Co., c/o O. M. Mason, is having plans prepared for a 3 story cotton mill, including a steam heating system. About $300,000. Lockwood, Green & Co., Hanna Bldg., Cleveland, Archt. and Engr.

Mich., Howell—The city will soon award the contract for furnishing labor and material for water-works improvements including reservoir, 2 motor driven centrifugal pumps, etc. About $25,000. G. F. Dailey, City Clk. Holland, Ackerman & Holland, 106 East Liberty St., Ann Arbor, Engrs.

Ill., Paxton — The Bd. Educ. c/o J. C. Strong, Pres., is having plans prepared for a 3 story high school, including a steam heating system on East Center St. About $400,000. Architect not yet selected.

Wis., Milwaukee — The Prospect Towers Corp., c/o A. C. Eschweiler, 141 Wisconsin St., Archt., plans to build a 4 story apartment house on Prospect Ave. About $500,000.

Ia., Anamosa—Jones County, c/o Lee Van Kirk, Co. Auditor, is having preliminary plans prepared for a 3 story court house. Heating and plumbing contracts will be separate. About $350,000. W. E. Hulse & Co., 309 Securities Bldg., Des Moines, Archt.

Ia., Corning — The city voted $60,000 bonds to build an electric light and power plant. Noted March 1.

Ia., Clinton—The Chicago & Northwestern R.R., 399 West Jackson Blvd., Chicago, Ill., plans to build a 2 story, artificial ice plant including refrigerating system, etc. About $50,000.

Ia., Des Moines—The Iowa Natl. Bank, c/o H. A. Miller, Pres., Fleming Bldg., is having plans prepared for remodeling the 7 story bank and office building now known as the Citizens Natl. Bank Building, on 6th and Walnut Sts. A steam heating system will be installed in same. About $300,000. Boyd & Moore, 1020 West Grand Ave., Archts.

Ia., Des Moines—The Keith Furnace Co., 200 Court Ave., will soon award the contract for a 1 story, 46 x 264 ft. tin factory and a 99 x 142 ft. foundry building on 26th and Dean Aves. About $200,000. Boyd & Moore, 1020 West Grand Ave., Archts.

Ia., Dubuque—E. H. Palen, Secy. of the Bd. Educ., Bank & Insurance Bldg., is having plans prepared for a 3 story high school in the Northend. About $325,000. J. W. Royer, Urbana, Ill., Archt.

Kan., Wichita—The Bd. Educ. is having plans prepared for a 3 story high school including a steam heating system. About $1,000,000. Lorentz & Schmidt & Co., 121 North Market St., Archts.

Kan., Wichita—The Orpheum Bldg. Co., c/o Mr. Gray and Dr. Barr, 702 Schenectady Bldg., will receive bids until July 13 for a 3 story, 40 x 90 ft. and a 7 story, 50 x 140 ft. theater building including a steam heating system on 1st and Lawrence Sts. About $700,000. John E. Eberson, 64 East Van Buron St., Chicago, Ill., Archt.

Neb., Blair—The United Danish Lutheran Church, c/o A. W. Lund, Secy., 2211 28th Ave., South, Minneapolis, Minn., plans to construct buildings, including a steam heating system for Dana college. About $500,000. Architect not yet selected.

Mo., Calhoun—C. Neilson will receive bids until July 15 for steam shovels, pumps, dummy engines, etc. About $25,000.

Mo., Kansas City—The City of Kansas is having plans prepared for 2 Memorial Buildings. About $2,000,000. H. Van Buren Magonigle, 101 Park Ave., New York City, Archt. and Engr.

Mo., Marble Hill — The city, c/o C. Alexander, Lutesville, plans to build an electric light plant. About $50,000. Engineer not yet selected.

Mo., St. Louis—The Missouri Pacific R.R., c/o Dr. Vasterling, 2102 South Compton St., plans to build a 6 story, 100 x 200 ft. hospital, including a steam heating system, on Grand and Shaw Sts. About $450,000. C. H. Wray, Rialto Bldg., Archt.

Mo., Urich—The City will install electric units, including generators, motors, engines, boilers, etc. About $10,000. Work will be done by day labor.

Tex., Denison — The Denison Hotel Co. will receive bids until July 11 for a hotel, including a steam heating equipment. About $225,000. Robertson & Griesbubech, S.W. Life Bldg., Dallas, Archts.

Okla., Sayre — The city voted $68,500 bonds to improve the waterworks system and electric power plant, here. V. V. Long & Co., Colcord Bldg., Oklahoma City, Engr.

Cal., San Diego—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received bids for the installation of a steam distribution system and returns from C. H. Julian, 1228 Second St., San Francisco, $10,949. Thos. Haverty Co., 8th and Maple Sts., Los Angeles, $12,480. John R. Proctor, 120 Liberty St., New York City, $12,900.

Que., Asbestos — The Canadian John Manuele Co., St. James St., Montreal, will receive bids about July 15 for a complete asbestos factory including equipment, here. About $350,000.

Ont., Hamilton—R. H. Foster, Secy. of the Bd. Educ., will receive bids until July 18, for a 4 story main school bldg., with 3 wing additions, including steam with electric driven mechanical ventilation system on Wentworth St., N. About $800,000. Whitton & Walsh, Hamilton Provident & Loan Bldg., Archts.

Ont., Hamilton—The Hospital B. I. c/o W. F. Longrill, plans to build a 5 story, 45 x 175 ft. nurses home including a steam heating system on Barton and Euclid Aves. About $300,000. Secord & Murton, 48 Home Bank Bldg., Archts.

Ont., Ottawa—R. C. Desrochers, Secy. Dept. of Pub. Wks., will receive bids until July 22 for the installation of an oil engine and generator in the power house at William Head, the quarantine station.

Ont., Ottawa—The Ottawa Hydro Electric Comn., 109 Bank St., will receive bids until July 15 for low tension cables for power and light service. J. E. Brown, Mgr.

Ont., Saulte Ste Marie—J. T. Later, Secy. of High School Bd., will receive bids until July 18 for a 3 story high school including a steam heating system on Tancred and Wellington Sts. About $350,000. Findlay & Foules, 527 Queen St., E., Archt.

Ont., St. Thomas—The Bd. Educ., c/o W. B. Doherty, City Hall, plans to build a technical school on Talbot St. About $350,000.

Ont., Tilbury—The City Council plans to install four 2 stage, gasoline driven, centrifugal pumps to have 300 Imp. g.p.m. and one 800 Imp. g.p.m. electric pump. All for 80 to 100 lb. fire pressure. About $30,000.

Ont., Toronto—The General Accident Insurance Co. of Canada, Continental Life Bldg., will receive bids about July 15 for an 8 or 10 story, 81 x 87 ft. office building including a steam vacuum heating system on Bay and Temperance Sts. About $300,000. T. H. Hall, Genl. Mgr. F. S. Baker, 67 Yonge St., Archt.

Ont., Toronto—The Northern Hotels Co., Ltd., Mossop Hotel, plans to build a 15 story hotel, including a steam heating system on Yonge St. About $500,000. Molesworth, West & Secord, 43 Victoria St., Archts.

Ont., Walkerville—The School Bd., c/o W. Thorburn, Secy., 83 Devonshire Rd., plans to build a high school, including a steam heating and mechanical ventilation system on Huron St. About $450,000. J. R. Boyde, Bartlett Bldg., Windsor, Archt.

Ont., Wingham—W. A. Galbraith will receive bids until July 19 for a pump house and installing one electric driven centrifugal pump about 500 gpm. About $25,000. Chipman & Power, Mail Bldg., Toronto, Engrs.

Man., Winnipeg — The Winnepeg School Bd. will receive bids until July 26 for a 3 story,, 265 x 318 ft. collegiate school, with additional work shops, including steam heating equipment on the corner of Alverstone and Wellington Sts. About $1,000,000. J. N. Semmens, 508 Great West Perm Bldg., Archt.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		53c. per ft.
Common, 2½-in.		60–5%

	Air		
	First Grade	Second Grade	Third Grade
¾-in. per ft.	$0.33	$0.23	$0.15

Steam—Discounts from List

First grade... 40–10% Second grade.....50–5% Third grade..60–5%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 70-5% Best grade..... 50-10-5%
Standard..... 65-5%

LEATHER BELTING—Present discounts from list in fair quantities (½ doz. rolls):

Light Grade	Medium Grade	Heavy Grade
50–5%	45%	40%

RAWHIDE LACING { For cut, best grade, 50–10%, 2nd grade, 60%. For laces in sides, best, 41c per sq. ft.; 2nd, 39c. Semi-tanned: cut, 50%; sides, 43c per sq. ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$1.00
Asbestos for high-pressure steam	2.00
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.70
Compressed asbestos sheet	1.00
Wire insertion asbestos sheet	1.50
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.25
Asbestos wick, ½- and 1-lb. balls	.75

PIPE AND BOILER COVERING—Below are part of standard lists, with discounts.

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure..... 25% off

For low-pressure heating and return lines { 4-ply..... 50% off; 3-ply..... 52% off; 2-ply..... 54% off

PORTLAND CEMENT—New York, $2.80 without bags, in cargo lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.23 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York		
	Current	Cleveland	Chicago
White	7.50@10.00	12.50	14.25
Colored mixed	5.50@ 9.00	9.00	12.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$55.00	$65.00
Chicago	41.00	43.50

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.80	$0.86	$0.87

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	13.00	14.50	15.00	16.50	13.00	15.00
25- and 50-lb. kegs	13.25	14.75	15.25	16.75	13.25	15.25
12½-lb. keg	13.50	15.00	15.50	17.00	13.50	15.50
1-lb. cans	16.00	17.50	17.50	18.50	16.00	17.00
5-lb. cans	18.00	19.50	19.50	19.50	18.00	18.00

500 lb. lots less 10% discount; 2000 lb. lots less 10–2½%.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ½ and smaller	50%	60%	45%
Tinned	45%	60%	30%

Structural rivets, ½, ¾, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York.....$4.65 Chicago.....$4.53 Pittsburgh.....$3.70

Boiler rivets, same sizes:

New York.....$4.75 Chicago.....$4.63 Pittsburgh.....$3.80

REFRACTORIES—Prices in carlots:

Chrome brick, eastern Shipping points	net ton	60@ 65
Chrome cement, 40@45% Cr_2O_3	net ton	30@ 35
Chrome cement, 40@45% Cr_2O_3, in sacks	net ton	33@ 38
Clay brick, 1st quality, fire clay, 9-in. shapes, Pennsylvania, Ohio and Kentucky	per 1000	55@ 60
Clay brick, 2d quality, fire clay, 9-in. shapes Pennsylvania, Ohio and Kentucky	per 1000	45@ 50
Magnesite brick: 9-in. straight	net ton	70@ 75
Magnesite brick: 9-in. arches, wedges and keys	net ton	77@ 82
Magnesite brick: Soaps and splits	net ton	98@ 105
Silica brick: Chicago district	per 1000	40@ 45
Silica brick: Birmingham, Ala.	per 1000	38@ 42
Silica brick: Mt. Union, Pa.	per 1000	35@ 40
Magnesite cement: Eastern shipping point, in bags	net ton	50@ 55
Magnesite cement: Eastern shipping point, in bags	net ton	47@ 52

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
Best grade	70.00	41.00	35.00
Commercial	30.00	14.75	9.00

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Chicago	Cleveland
Round shafting or screw stock, per 100 lb. base	$4.63	$4.63	$4.25
Flats, square and hexagons, per 100 lb. base	5.13	4.63	4.75

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	75%
Boiler flanges	55%
Boiler lugs	Net list
Boiler stay bolts	60%
Boiler patch bolts	Net list
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	Net list
Pressed steel boiler hangers	Net list

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the Pittsburgh basing card of April 13, 1921:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62½	50	⅜	33½	18½
			1 to 1½	35½	20½

LAP WELD

2	54½	58½	15	42½	...
2½ to 6	58½	46	2	30½	16½
7 to 12	54½	41	2½ to 6	33½	20½
13 and 14	45	...	7 to 12	29½	16½

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60½	49	1 to 1½	35½	21½
2 to 3	61½	50			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	52½	41	2	31½	18½
2½ to 4	56½	45	2½ to 4	34½	22½
4½ to 6	55½	44	4½ to 6	33½	21½
7 to 8	50½	37	7 to 8	24½	12½
9 to 12	45½	32	9 to 12	19½	7½

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.27
1¼	.....	.....	.26
1½	.....	.....	.24
1¾	$0.2200	$0.2855	.26
2	.2100	.2463	.25
2¼	.2328	.2814	.29
2½	.2760	.3330	.36
2¾	.3128	.3774	.39
3	.3496	.4170	.43
3¼	.4140	.4939	.51
3½	.3840	.5027	.55
4	.4880	.6390	.72

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2¼ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3¼ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 50.00(net)	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

Less than coil lots	15%	10%
Coils to 1,000 ft	25%	20%
1,000 ft. and over	35%	25%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever-Ready:

	Each, Net
Less than 12	$0.40
12 to 50	.34
50 to 125 (bbl.)	.30½
125 (bbl.) or over	.29

CONDUIT, Price per 1,000 ft.; ELBOWS AND COUPLINGS, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

	Conduit		Elbows		Couplings	
Size, In.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.
½	$71.40	$76.50	$16.91	$18.01	$6.23	$6.65
¾	94.00	100.00	22.25	23.75	8.90	9.50
1	134.30	144.50	32.93	35.15	11.57	12.35
1¼	181.70	195.50	42.75	45.00	16.15	17.00
1½	217.20	233.70	57.00	60.00	19.95	21.00
2	292.30	314.50	104.50	110.00	26.60	28.00
2½	462.10	497.30	171.00	180.00	38.00	40.00
3	604.30	65.00	456.00	480.00	57.00	60.00
3½	754.40	818.80	1,007.00	1,060.00	76.00	80.00
4	910.00	980.00	1,163.75	1,225.00	95.00	100.00

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.
⅜	250	$0.05½
½	250	.06
¾	250	.09
⅞	200	.12
1	200	.15
1¼	150	.18
1	100	.25
1½	100	.33
1½	Odd lengths	.40
2	Odd lengths	55

100 ft. and over.... 60%
Coils..... 50%
Less coils, 40%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.10	D. P. D. B.	$0.38
D. P. M. L.	.18	T. P. to D. P. S. B.	.23
T. P. M. L.	.28	T. P. S. B.	.34
D. P. S. B.	.20	T. P. D. B.	.55

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.45	$1.15	$1.45
T. P. M. L.	.63	1.60	2.15
D. P. S. B.	.57	1.45	.....
T. P. S. B.	1.04	2.10	.....
D. P. D. B.	.99	2.65	.....
T. P. D. B.	1.70	4.80	.....
T. P. to D. P. D. B.	1.15	3.40	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$14.65
No. 16 cotton twisted	17.30
No. 18 cotton parallel	17.65
No. 16 cotton parallel	20.45
No. 18 cotton reinforced heavy	24.00
No. 16 cotton reinforced heavy	27.80
No. 18 cotton reinforced light	22.70
No. 16 cotton reinforced light	26.55
No. 18 cotton Canvasite cord	17.75
No. 16 cotton Canvasite cord	25.00

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.,	100	$0.25	3-amp. to 30-amp.,	100	$0.40
35-amp. to 60-amp.,	100	.035	35-amp. to 60-amp.,	100	.60
65-amp. to 100-amp.,	50	.90	65-amp. to 100-amp.,	50	1.50
110-amp. to 200-amp.,	25	2.00	110-amp. to 200-amp.,	25	2.50
225-amp. to 400-amp.,	25	3.60	225-amp. to 400-amp.,	25	5.50
425-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount: Less 1-5th standard package, 40%; 1-5th to standard package, 45%; standard package, 50%.

RENEWABLE FUSES, ENCLOSED—

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50 ea.	$1.10 ea.	100	10
35 to 60-amp.	1.00 ea.	1.25 ea.	100	10
65 to 100-amp.	2.00 ea.	3.00 ea.	50	5
110 to 200-amp.	4.00 ea.	5.00 ea.	25	5
225 to 400-amp.	7.50 ea.	11.00 ea.	25	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1

RENEWAL LINE FOR ABOVE FUSES—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$4.00
0-30 ampere, less than standard package	4.50

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.40	$0.45	100	75	$0.75	$0.80	50
15	.40	.45	100	100	1.10	1.20	24
25	.40	.45	100	150	1.55	1.65	24
40	.40	.45	100	200	2.10	2.25	24
50	.40	.45	100	300	3.15	3.35	24
60	.45	.50	100				12
				500	4.60	4.85	12
				750	6.50	6.85	8
				1,000	7.50	7.85	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.24
Composition 2-piece attachment plug	.32
Swivel attachment plug	.16
Current taps	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 6.30	$ 8.10	$9.55	$15.65
12	8.25	10.20	11.95	19.70
10	10.95	13.00	15.20	25.50
8	14.75	17.00	20.10	34.00
6	.....	.....	30.45	.....
4	.....	.....	41.00	.....
2	.....	.....	60.50	.....
1	.....	.....	80.95	.....
0	.....	.....	95.70	.....
00	.....	.....	113.90	.....
000	.....	.....	136.65	.....
0000	.....	.....	165.85	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	Keyless Each	Pull Each	¾ In. Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.50	$0.39	$0.36	$0.56

Less 1-5th standard package	+25%
1-5th to standard package	List
Standard package	20%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B. & S. regular spools (approx. 8 lb.)	37c. lb.
No. 18 B. & S. regular 1-lb. coils	38c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 40c. lb., 100 lb. lots	38c. lb.
Rubber tape, ¾ in., less 100 lb. 40c. lb., 100 lb. lots	38c. lb.
Wire solder, less 100 lb. 35c. lb., 100 lb. lots	30c. lb.
Soldering paste, 2 oz. cans	$1.50 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.30	7.30
200	4.40	6.76	10.14	13.50

Discounts:

Less than $10.00 list value	15%
$10 to $25 list value	net list
$25 to $50 list value	5%
$50 to $200 list value	20%
$200 list value or over	25%